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TECHNICAL REPORT

AD

REPORT #6003

7.62MM HEAT TREATED STEEL CARTRIDGE CASE

BY

PHILIP B. TAYLOR
SIDNEY WHITE

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June 1971

DEPARTMENT OF THE ARMY
FRANKFORD ARSENAL
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7.62MM HEAT TREATED STEEL CARTRIDGE CASE

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Ammunition Development and Engineering Laboratories
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

June 1971

TABLE OF CONTENTS

APPENDICES

SUMMARY

Under direction of the Secretary of Defense and in accordance with the Copper Conservation Program, the development of an improved heat treated steel case for 7.62mm ball and tracer cartridges was begun at Frankford Arsenal in 1966.

A previous 7.62mm steel cartridge-case Product Improvement program was conducted at Lake City Army Ammunition Plant and Frankford Arsenal, but was discontinued in 1957 and 1960 respectively, without conclusively establishing a functional cartridge case. A process was established and cartridges were manufactured but were never tested by USATECOM. Past efforts demonstrated though, through manufacture of two million steel-cased cartridges at Lake City, and lesser quantities at Frankford Arsenal, that a heat treated 7.62mm steel cartridge case was feasible. however, improvements were required in material, simplification of process, heat treatment, surface coating, and control of quality, acceptability, and uniformity.

Work under the present program was based largely upon the results obtained from earlier efforts, and resulted in a considerably-improved cartridge case, meriting TECOM evaluation for standardization; this case was manufactured utilizing improved material and simplified processing methods. Major changes and deletions to previous processes were made. Induction heat treating with oriented quench and a varnish surface coating were employed; and operations such as mouth and body anneal, retaper and replug, and zinc-plate cronak treat were eliminated. In addition, tooling, lubrication, and controls were improved.

The present program was planned and conducted in two phases. Phase I included the evaluation of previously established processes, the examination and testing of the components and ammunition produced, and the acquisition and installation of the necessary process equipment. Temporary manufacturing procedure (TMP) 301 was established, which specified processing methods using Republic C1025 steel, under which developmental quantities of cases were manufactured. Process modifications were made to TMP 301 on a lot-by-lot basis until proof testing indicated that a satisfactory process had been obtained.

Phase II of the program required the production of approximately one million steel-cased cartridges under TMP 305, using Sharon C1025 steel, which was based upon the modifications to TMP 301 found most satisfactory during Phase I of the program.

Cartridge case quantities for ET/ST were shipped to the specified test locations, namely, APG (tests not completed); USA Infantry Board, Fort Benning (tests completed); USA Armor and Engineer Board, Fort Knox (tests suspended pending APG outcome); and USA Arctic Test Center, Fort Greely (tests completed). Official TECOM statement of position is dependent on the outcome of Engineer Tests at APG, which have been delayed due to higher priority work.

Since the start of the steel case program in 1966, supplies of copper in the free world market have become more stable and less costly. The Copper Industry Trade Institute has projected world copper supply over the next few years and has compared this with projected copper demand for the same period. Forecasts indicate that there will be a surplus rather than a shortage of copper in the near future; much of this world copper however, is mined in countries with unstable governments, and labor problems are a continual threat to copper supplies. As a result of this apparently-improving condition of copper supplies, present plans call for complete documentation of steel-case manufacturing techniques, as developed to date, in the event that copper again becomes scarce. While determination of the ultimate degree of success or failure of the program rests with ET/ST results, this report relates the present state of the art of heat treated steel case development and manufacture.

PROCESS METALLURGY

In addition to routine checks of hardness, microstructure, material quality, etc., conducted throughout processing, two comprehensive process evaluations were made to determine the metallurgical adequacy and suitability of the processes used.

The first of these evaluations was performed during processing under TMP 301 to investigate the effects of different processing methods and to predict the probable outcomes of the various methods. The evaluation is essentially a study of case lot 6, (see Appendix A) with appropriate evaluations of components from other lots, when these components differed metallurgically from those of lot 6. It should be noted that lot 6d was manufactured utilizing the process which was subsequently adopted for processing of TMP 305.

The metallurgical evaluation of processing under TMP 305 shows representative hardnesses and microstructures of sample components taken from each lot, at successive stages of processing. Note that case lot numbers 1 thru 8 listed in the TMP 305 evaluation bear no relationship to case lots 1 thru 9 in TMP 301 processing.

The steels used for manufacture of the heat treated case were both of AISI grade C1025. Manufacturer's ladle analyses and Frankford Arsenal check analyses, given in Table I, show chemical compositions to be within AISI limits for these analyses, respectively. Both steels were fine-grained, aluminum-killed steels having low phosphorus and sulfur content, making them ductile and suitable for deep drawing.

TABLE I

CHEMISTRY of C1025 STEEL STRIP

Manufacturer's Ladle Analysis

Manufacturer	C	Mn	P	S	Si	Al
Republic	.24	.43	.010	.022	-	-
Sharon	.24	.34	.010	.016	.04	-

Frankford Arsenal Check Analysis

Manufacturer	C	Mn	P	S	Si	Al
Republic	.22	.44	.003	.021	< .10	.03
Sharon	.25	.35	.006	.018	< .10	.05 - .10

METALLURGICAL EVALUATION OF DEVELOPMENTAL CASE LOTS MANUFACTURED FROM REPUBLIC C1025 STEEL UNDER TMP301

1. Strip. The as-received material was relatively fine grained (6 to 7) with most of the carbides in spheroidal form (see Figures 1 and 2). The hardness is between Rb 60-65. Prior to spheroidization, the structure of this strip consisted of areas of pearlite and ferrite. The scattered areas of spheroidization result from transformation of the carbide in the pearlite from lamellar to spheroidal form.

2. Cup.

(a) As-drawn. The sidewalls of these cups were work hardened approximately 30 points to Rb 93. Unrestricted grain flow was evident in all areas. Following is a typical hardness pattern for this piece (all readings are Rb and are taken at 1/8 inch intervals).

```
Rb 93                93
   93                92
      86   66   72   88
```

(b) Annealed (1320°F). This treatment brought the hardness down to the level of the original strip material.

```
Rb 64                64
   63                64
      57   60   62   58
```

3. First draw piece.

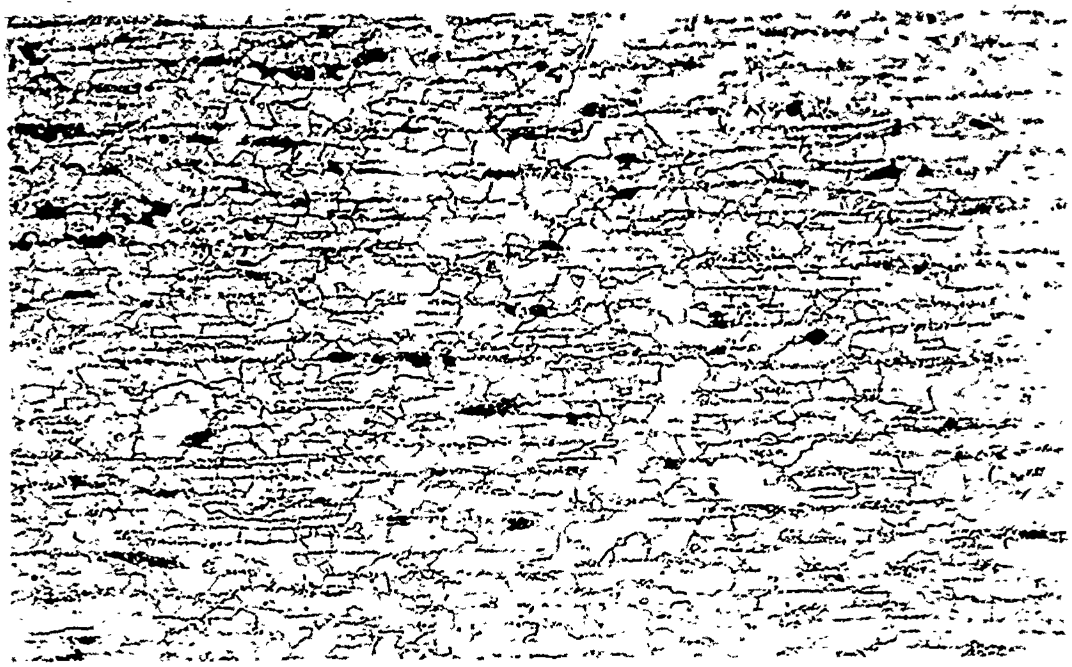


Figure 1   Neg. #2036-1966   Mag: 100X

Longitudinal view of Republic Steel strip, as received. Spheroidal carbides are not discernable at this magnification. It can be seen, however, that these carbides formed only in former pearlite areas. Grain Size: 6 to 7

Figure 2   Neg. #2037-1966   Mag: 500X

Same as Figure 1 , but spheroids are visible at this magnification.

(a) As-drawn. No metallurgical defects were detected at this stage of the process. The sidewall was work hardened to Rb 96.

Rb	96					96
	96					96
	95					96
	95					95
		88	64	64	85	

(b) Annealed (1340^{o}F). This piece was a bit harder than the strip or annealed cup. Nevertheless, it was adequate to permit formation of the second draw piece with little difficulty.

Rb	66					67
	66					66
	65					66
	64					66
		58	60	62	66	

4. Second draw piece.

(a) As-drawn. The sidewall of this process piece was cold worked to Rb 99. This is only one point below the finished item requirement of Rb 100 (Rc 22).

Rb	99					99
	99					99
	99					98
	98					97
	96					92
	86					84
		85	75	72	79	

(b) Annealed (1320^{o}F). This piece is a bit harder than the second draw piece after annealing.

Rb	60					66
	68					67
	69					68
	68					68
	68					67
	64					68
		72	66	68	57	

5. Third draw piece.

(a) Annealed prior to third draw. This piece did not get quite as hard as the second draw piece.

Rb 85	90
93	91
95	93
91	94
96	94
94	93
95	94
92	95
90	96

86 78 77 84

(b) Not annealed prior to third draw (lot 9). Some pieces were drawn without an anneal in an attempt to attain the required sidewall properties without a heat treatment. However, it appears that the spheroidized structure had reached its maximum hardness at second draw. An increase in hardness of only one point, from Rb 99 to Rb 100 was achieved.

Rb 94	99
99	100
99	100
100	100
100	100
99	100
95	96
91	93
99	99

88 75 78 92

This piece does not meet the sidewall requirements of the item specification.

(c) Hardened and tempered at 1250°F prior to third draw (lot 9). This treatment was performed in an effort to attain the required properties without necessitating heat treatment of the finished case. With this treatment, cold work is done on a tempered martensite rather than a spheroidized structure. However, the hardness again did not exceed Rb 100.

Rb 88	91
99	97
99	99
99	100
100	97
97	99
99	98
98	94
97	96
97	98

95 89 91 94

(d) Annealed after second draw, beaded and body annealed (preparatory to tapering) after third draw. The body anneal is performed by direct flame impingement. As a result, control of the microstructure is very poor. In most instances, the mouth area is heated above the critical temperature producing a ferrite-pearlite structure. The softest point occurs just below the shoulder where the effects of spheroidization are not destroyed (see Figures 3-5).

Rb 74	73
72	71
65	69
59	58
85	88
93	95
96	96
98	97
99	98
99	99

94 90 89 95

6. Un-heat-treated case (annealed prior to third draw).

(a) Body annealed prior to tapering. The various microstructures present in this piece are shown in Figures 3, 4 and 5. Figure 3 represents the as-drawn sidewall in the area left unaffected by the body anneal. Figure 4 represents the softest area on the case, approximately 1 1/4 inch from the base end. Spheroidization has been retained, the structure has been formed through recrystallization of the cold-worked sidewall. Figure 5 is from the mouth area. The temperature in this area exceeded the lower critical temperature during body anneal resulting in the formation of pearlite during cooling. The existance of the soft area in the sidewall allowed wrinkling to occur during tapering. This condition resulted in sidewall failures during ballistic testing. Following is a hardness pattern for this piece:

Distance from Base (in.)	Hardness 0°	180°
1.875	Rb 89	96
1.500	79	80
1.250	65	68
1.000	97	94
.750	94	93
.500	92	92
.250	91	91

Figure 3 Neg. #530-1966 Mag: 500X

Mid-Sidewall position, 1-1/8 inch from the head, before heat treatment. The piece has been body annealed and tapered. The structure is essentially ferritic with spheroidal carbides. The effect of cold working is still evident, indicating that body annealing had very little influence in this area.

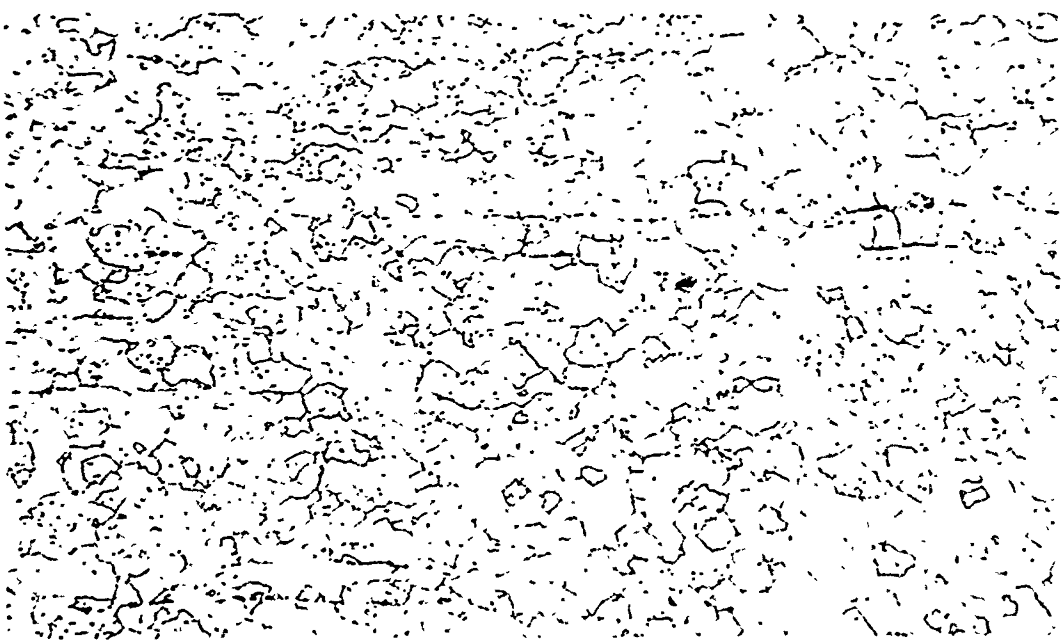


Figure 4 Neg. #531-1967 Mag: 500X

Same as Figure 3 , but 1-1/2 inch from head. The steel in this area recrystallized during body anneal. This is the softest area of the case at this stage, and as a result wrinkles are produced during tapering.

Figure 5 Neg. #532-1967 Mag: 500X

Same as Figures 3 and 4, but 1-7/8 inch from base (in mouth area). The presence of carbide in other than the spheroidal form shows that this area exceeded the lower critical temperature during body anneal. Ideally, this should be the softest area of the case before tapering.

Base Position	Hardness 0°	Hardness 180°
A	89	89
B	90	88
C	94	96
D	96	97

(b) No body anneal prior to taper. The body anneal was not performed in order to eliminate wrinkling. The wrinkles were successfully eliminated as were the ballistic failures.

Distance from Base (in.)	Hardness 0°	Hardness 120°
1.875	96	96
1.500	95	95
1.250	94	94
1.000	93	93
.750	93	91
.500	92	91
.250	91	89

Base Position	Hardness 0°	Hardness 180°
A	89	89
B	90	88
C	94	96
D	96	97

7. Heat treated case (lot 4). The following table shows the hardness pattern of several cases hardened by induction, and tempered at various temperatures for 75 minutes. These cases received a body anneal prior to tapering.

Distance from Base (in.)	As Quenched	Tempered 75 minutes at 800°F	850°F	875°F	900°F
1.969	Rb 92	Rb 61	Rb 66	--	Rb 69
1.937	98	62	75	Rb 64	68
1.875	Rc 29	85	88	79	86
1.831	--	--	--	87	--
1.715	41	97	97	--	93
1.675	--	--	--	94	--
1.500	46	Rc 26	Rc 24	Rc 24	Rc 20
1.250	51	28	26	24	23
1.000	51	28	26	24	23

Distance from Base (in.)	As Quenched	Tempered 75 minutes at 800°F	850°F	875°F	900°F
.750	50	28	26	25	23
.500	49	28	27	26	22
.250	50	29	26	26	24
Base Position					
A	50	29	25	25	22
B	49	29	26	25	22
C	49	29	26	25	24
D	49	29	26	26	24

All of the tempered pieces fall within the hardness range specified on the drawing as shown on the graph, Figure 5. The induction coil was positioned such that it heated directly only the body and head portions of the case. The natural conductivity of the material was relied upon to heat the mouth and shoulder areas. The cycle was such that the critical temperature was not exceeded in the mouth. As a result, this area did not harden, and a mouth anneal (for crimping) was not necessary. The tempering treatment was sufficient to bring the mouth within the required hardness range.

The microstructure of the as-quenched body is shown in Figure 7. This structure is essentially 100% martensite. The microstructure of various areas of the tempered body are shown in Figures 8-14. These photomicrographs illustrate the differential effect of heat treatment. The area from the upper sidewall to the base is essentially all tempered martensite. The shoulder and lower mouth area is a mixture of martensite and ferrite. The open end is primarily ferrite and spheroidal carbide with some areas of what appears to be pearlite. This is almost identical to the mouth area after body anneal; heat treatment had very little effect on this area other than to relieve the stresses introduced during tapering. Subsequent tempering was sufficient to bring this area within the required hardness range of R(15T) 82-86.

Hardness patterns for two heat treated cases which received no body anneal prior to taper (Lot 6D) are shown below. These pieces were tempered at 800°F for 75 minutes.

Distance from Base (in.)	Hardness No. 1 0°	No. 1 180°	No. 2 0°	No. 2 180°
1.934	Rb 66	Rb 65	Rb 65	Rb 64
1.875	67	73	68	78
1.831	70	77	72	81
1.500	75	89	85	92
1.250	96	96	99	96
1.000	Rc 30	Rc 24	Rc 31	23
.750	31	31	31	29

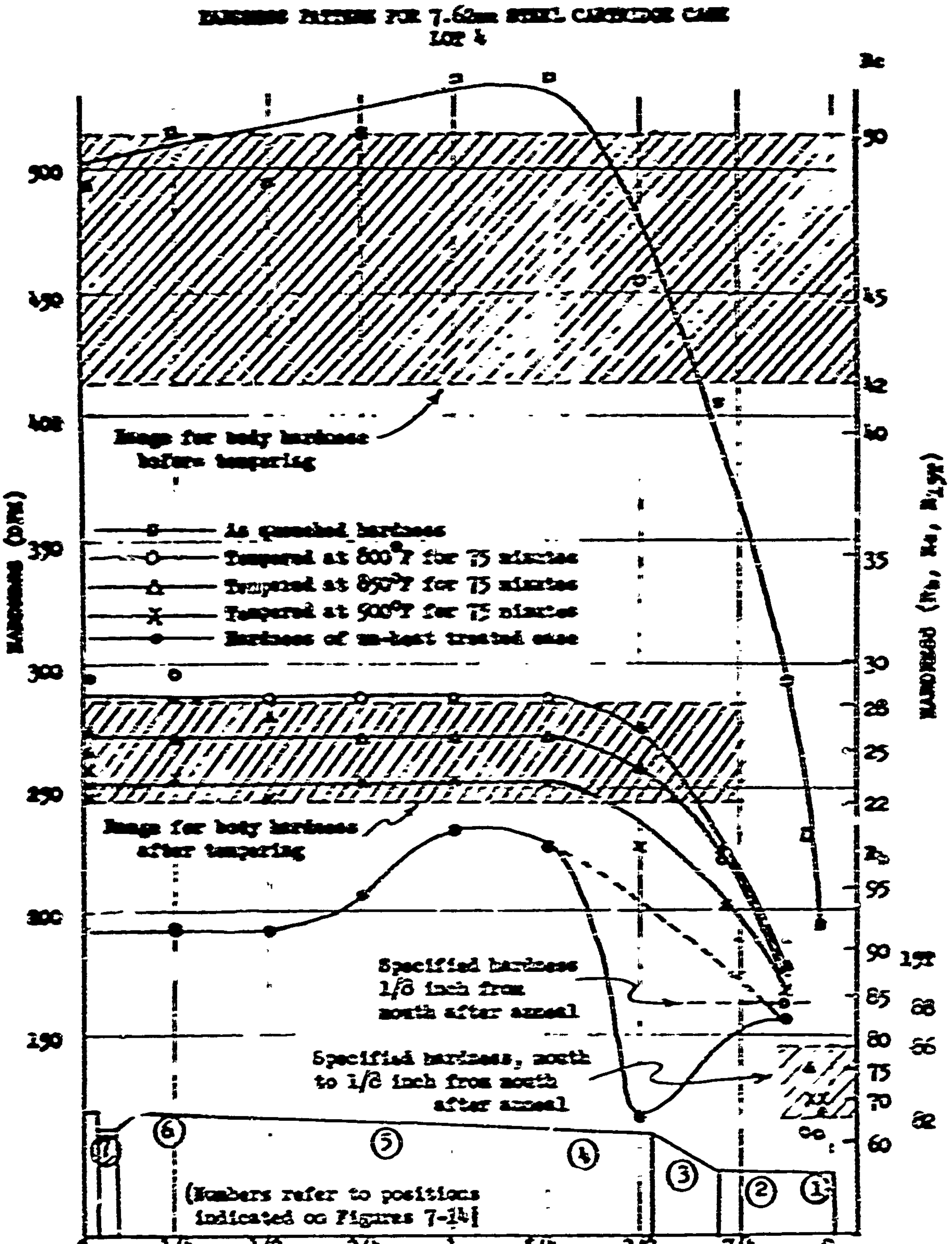


FIGURE 6. DISTANCE FROM HEAD (IN.)

Figure 7 Neg. #279-1967 Mag: 1,000X
As-quenched sidewall between positions 5 and 6 (See Figure 6). The structure, which has a hardness of R_c50, is primarily untempered martensite.

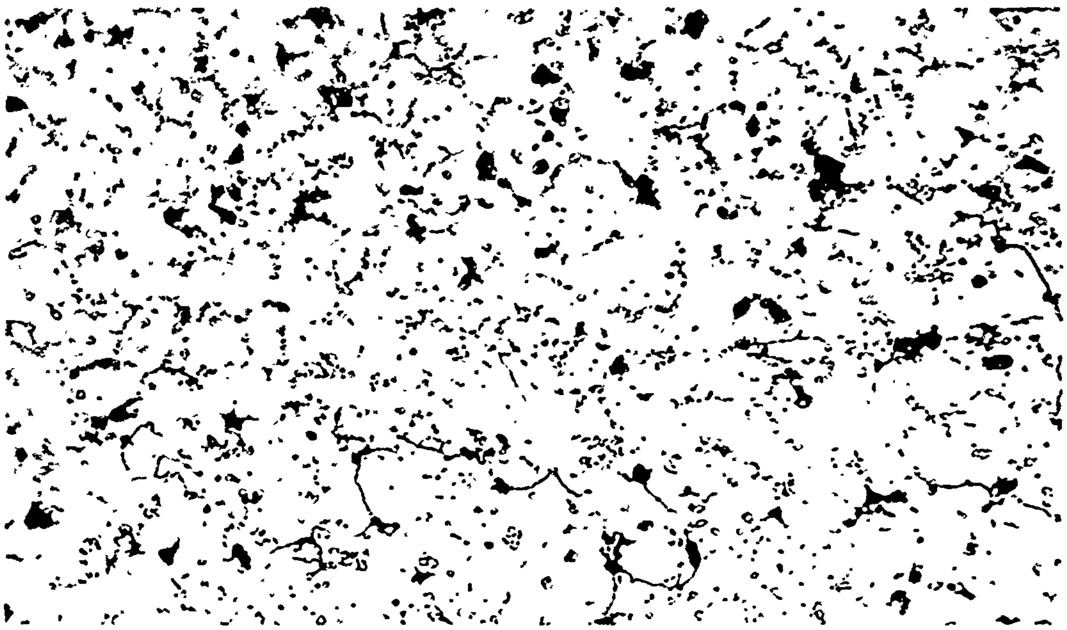


Figure 8 Neg. #280-1967 Mag: 1,000X
Mouth area of tempered case, position 1 (See Figure 6). This microstructure consists of ferrite, spheroidal carbide, and probably pearlite. Hardness is R_b65, which is sufficiently soft for crimping.

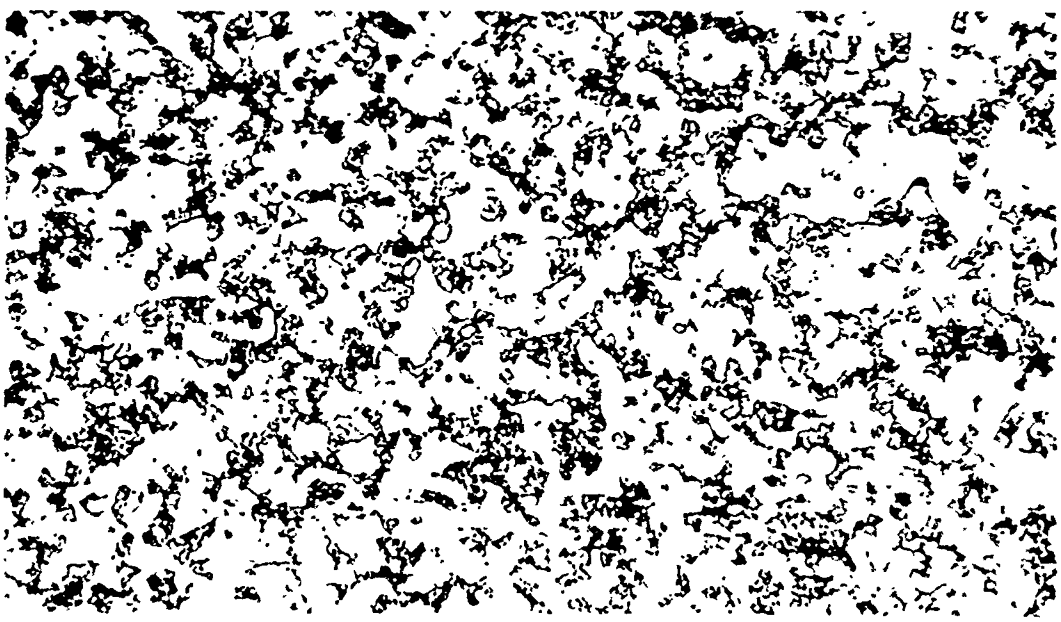


Figure 9 Neg. #281-1967 Mag: 1,000X
Lower neck, position 2 (See Figure 6). This dual microstructure consists of ferrite (white) and tempered martensite. This structure is typical of a steel held between the lower and upper temperatures prior to quench. (This area probably did rise above the upper critical temperature, but not for long enough to allow complete transformation to austenite).

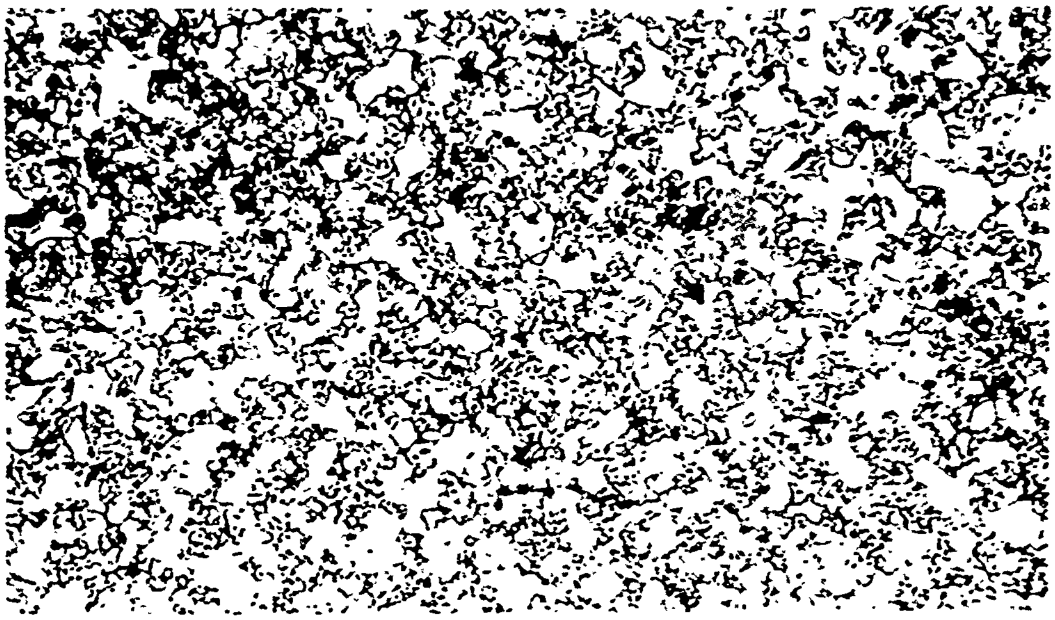


Figure 10 Neg. #282-1167 Mag: 1,000X

Shoulder, position 3. Same as position 2 but showing a higher ratio of martensite to ferrite. This area reached a higher temperature than position 2.

Figure 11 Neg. #283-1967 Mag: 1,000X

Upper sidewall, position 4. This area is primarily fine-grained tempered martensite but with small areas of untransformed ferrite.

Figure 12 Neg. #284-1967 Mag: 1,000X

Middle sidewall, position 5. This structure is almost fully martensite. Some non-metallic inclusions in the form of stringers are visible.

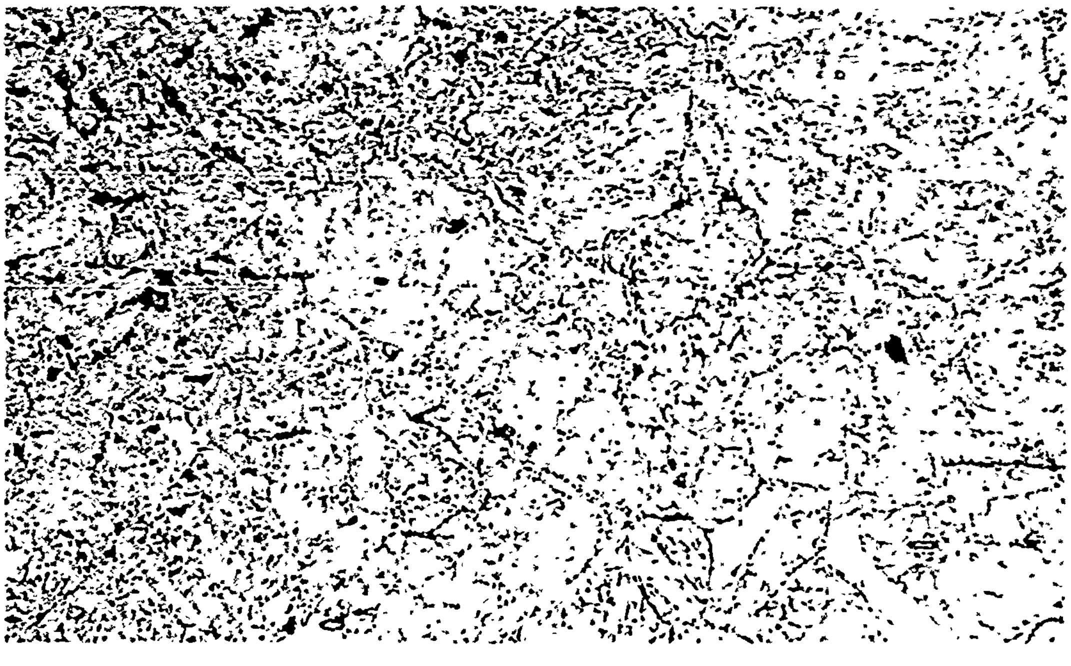


Figure 13 Neg. #285-1967 Mag: 1,000X

Lower sidewall, position 6. This area is also tempered martensite but the grains are larger than at position 5. It appears that some undissolved carbides remain in the matrix.

Figure 14 Neg. #286-1967 Mag: 1,000X
Head, position 7. This structure, also tempered martensite, exists at the center of the base or head area. This shows that the quench is adequate - all the austenite in the case is transforming to martensite as required.

Distance from Base (in.)	Hardness No. 1 0°	Hardness No. 1 180°	Hardness No. 2 0°	Hardness No. 2 180°
.500	31	31	31	31
.250	31	31	31	31
Base Position				
A	24	28	30	24
B	27	30	31	28
C	28	30	31	28
D	28	29	31	29

The mouth area is sufficiently soft to allow crimping. However, the sidewall is significantly harder than that obtained with previous lots. This accounts for the improved ballistic success achieved by this process.

METALLURGICAL EVALUATION OF CASE LOTS MANUFACTURED FROM SHARON C1025 STEEL UNDER TMP 305

Hardnesses and microstructures of TMP 305, lots 1 thru 8, are shown in table II and figures 15 thru 33 respectively; with few exceptions, hardness patterns are included for each process piece in these lots. The microstructures were obtained from lot-4 pieces; photographs from other lots are not included since all lots are essentially identical.

1. Strip (Figures 15 and 16) - The first 20 Sharon steel coils used for this program were, in general, harder than the Republic steel strip used for TMP 301. The ranges obtained for these coils (excluding 4, 5, and 6) are shown below (range of five readings):

Hardness of Sharon Steel Strip

Coil No.	Hardness (R_B)	Coil No.	Hardness (R_B)	Coil No.	Hardness (R_B)
1	64 - 69	10	66 - 67	16	70 - 71
2	67 - 69	11	65 - 66	17	67 - 68
3	67 - 70	12	64 - 65	18	70 - 72
7	65 - 67	13	65 - 66	19	69 - 70
8	65 - 69	14	66 - 67	20	65
9	64 - 67	15	67 - 69		

2. Cup (Figures 17 and 18) - The hardness of the sidewalls, as drawn, ranged from the low-to-mid 90's R_B. The bases exhibited very little increase over the strip hardness. After annealing, the sidewalls, with the exception of lots 7 and 8, were in the mid-to-upper 60's R_B. Lots 7 and 8 were in the low 60's R_B. The microstructure of an annealed cup shows that a relatively equiaxed ferrite matrix existed in both the sidewall and the base. (Since our primary interest was the condition of the process

Figure 15 Neg. #1694-1967 Mag 1000X

Sharon steel strip. Longitudinal section from coil #3, showing 90% spheroidization.

Figure 16 Neg.#1695-1967 Mag 1000X

Sharon steel strip. Transverse section from coil #3, showing grain size of 6 to 8.

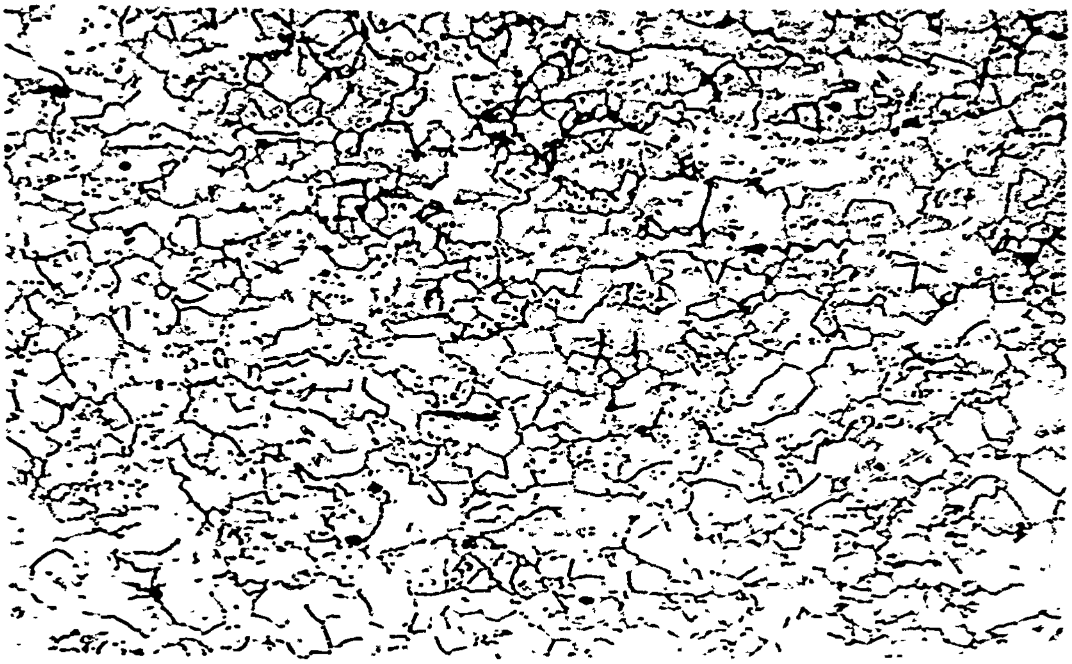


Figure 17 Neg. #2210-1967 Mag: 500X
Sidewall of annealed cup showing equiaxed ferrite. Hardness R_b 66-68.

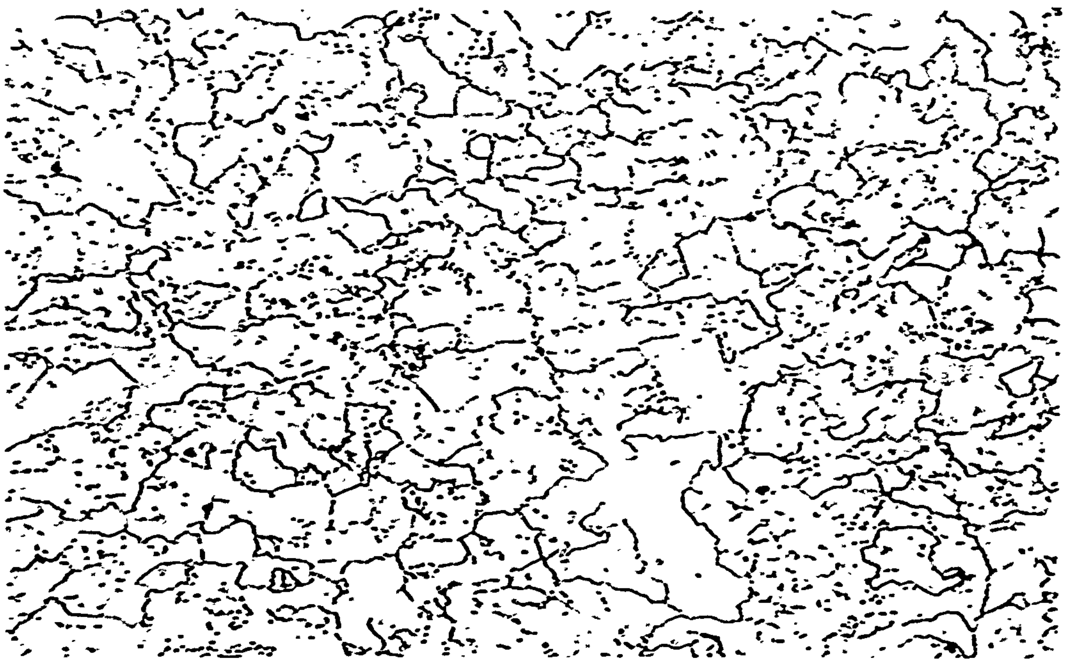


Figure 18 Neg. #2211-1967 Mag: 500X
Base of annealed cup showing equiaxed ferrite. Hardness R_b 62-72.

piece prior to subsequent forming, microstructures for the cups, first-draw pieces, and second-draw pieces were obtained in the annealed condition only).

3. First Draw Piece (Figures 19 and 20) - The sidewalls of the first-draw pieces were worked to hardnesses in the mid 90's R_B. After annealing, the sidewalls ranged in the mid 60's R_B, with the exception of lots 1 and 2. Based on 1-piece samples, lot 2 sidewalls were up over R_B 70, and lot 1 exhibited a reading of R_B 82; this was probably caused by improper annealing, but produced no excessive difficulties at second draw. The microstructure is essentially equiaxed ferrite and spheroidal carbide. The only evidence of previous working is in the longitudinal pattern of the carbides.

4. Second Draw Piece (Figures 21 and 22) - Second-draw piece sidewalls were worked to the hardness range R_B 94-101; after annealing, they exhibited hardnesses in the range R_B 60-69. The microstructure of the annealed piece is again equiaxed ferrite and spheroidal carbide.

5. Headed Piece (Figures 23, 24 and 25) - The hardness table (Table II) shows the condition of the third-draw piece in both the as-drawn and the headed condition. During the drawing operation, the sidewall was worked to a hardness of R_B 87-97. (Ignore the 2 1/4 and 2 1/2 inch positions since this material is removed at trimming). During heading, the head is hardened approximately 15 points R_B; the sidewall remained unchanged. The photomicrograph shows the sidewall in the cold-worked condition. The photomicrograph of the base was taken from a relatively unworked area. The cold shuts present on the internal radius do not represent a serious condition; cold shuts of this magnitude were present in all eight lots.

6. Tapered Case - These pieces were not body annealed prior to tapering; a slight hardness increase was noted in the mouth area.

7. Hardened Case (Figures 26 to 29) - All lots exhibited as-quenched hardnesses of R_C 50 or greater in the sidewall region. Head hardnesses, in general, ranged from R_C 46 to 50, indicating that this area was being quenched out, while the mouth area remained relatively soft. The microstructure of the sidewall and head is essentially untempered martensite, although some high-temperature transformation product, probably pearlite, is visible at the grain boundaries in the head area. The shoulder area contains a mixed structure of martensite and ferrite, indicating that transformation was not completed prior to quench. The mouth area is completely untransformed. The relatively fine-grained structure is the result of annealing the cold-worked structure produced during tapering.

8. Tempered Case (Figures 30 to 33) - Except for lots 1 and 6, the sidewall and head hardnesses of all cases are within the desired range (R_C 22 to 28). The R_C 31 exhibited by cases from lots 1 and 6 was probably the result of a short tempering time or low temperature. The mouth hardnesses of most cases were below the desired range of R_B 65 to 78; this did not cause any problem since the mouth is hardened somewhat during crimping. The microstructures of the base and sidewall are essentially tempered martensite. The shoulder area consists of tempered martensite and ferrite. The mouth area is ferrite, along with spheroidal carbides remaining from the original strip material.

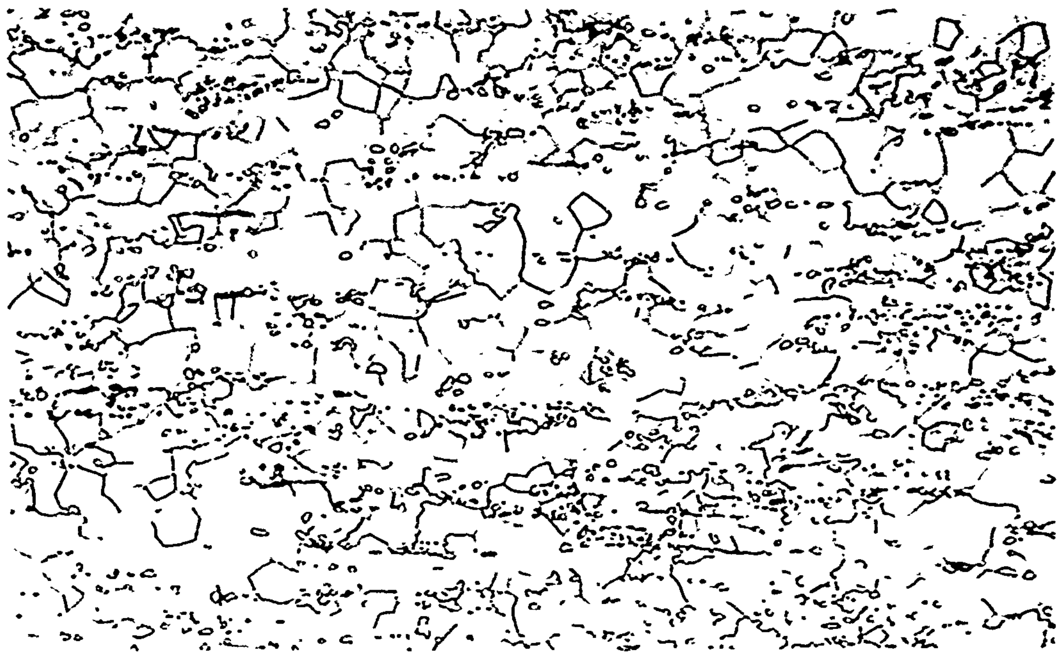


Figure 19 Neg. #2242-1967 Mag: 500X
Middle sidewall of annealed first draw piece showing equiaxed ferrite and spheroidal carbide. Hardness R_b 62-68.

Figure 20 Neg. #2243-1967 Mag: 500X
Base of annealed first draw piece sh ing equiaxed ferrite and spheroidal carbide. Hardness R_b 67-75.

Figure 21 Neg. #2477-1967 Mag: 500X
Upper sidewall of annealed second draw piece. The microstructure is equiaxed ferrite and spheroidal carbide. Hardness R_b 62-69.

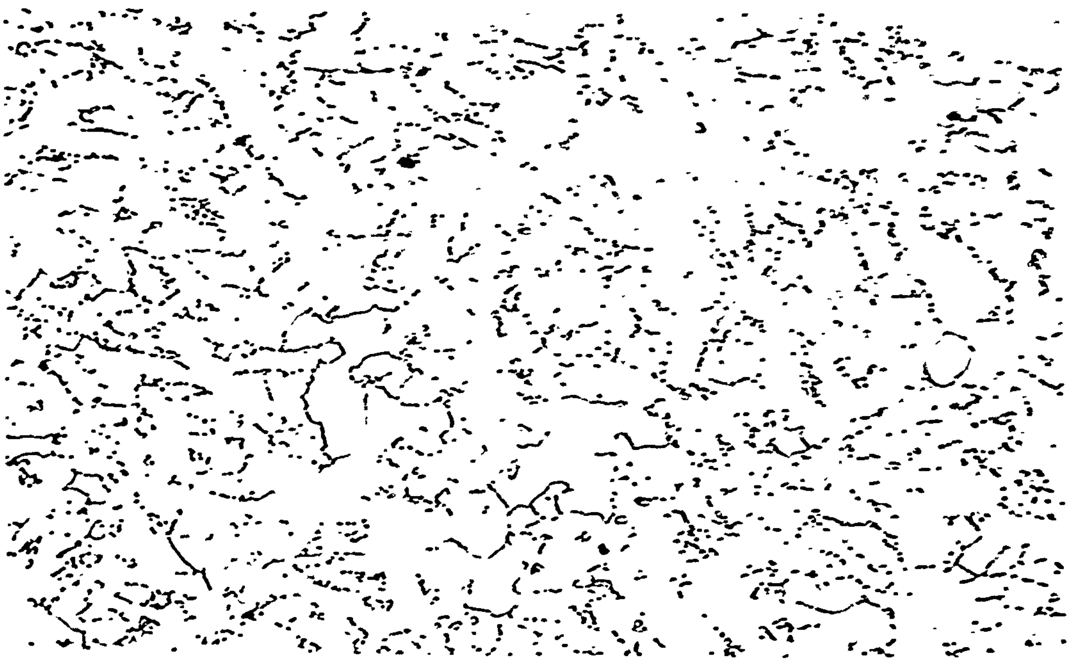


Figure 22 Neg. #2478-1967 Mag: 500X
Base of annealed second draw piece. Microstructure is similar to that exhibited by the upper sidewall. Hardness R_b 67-71.

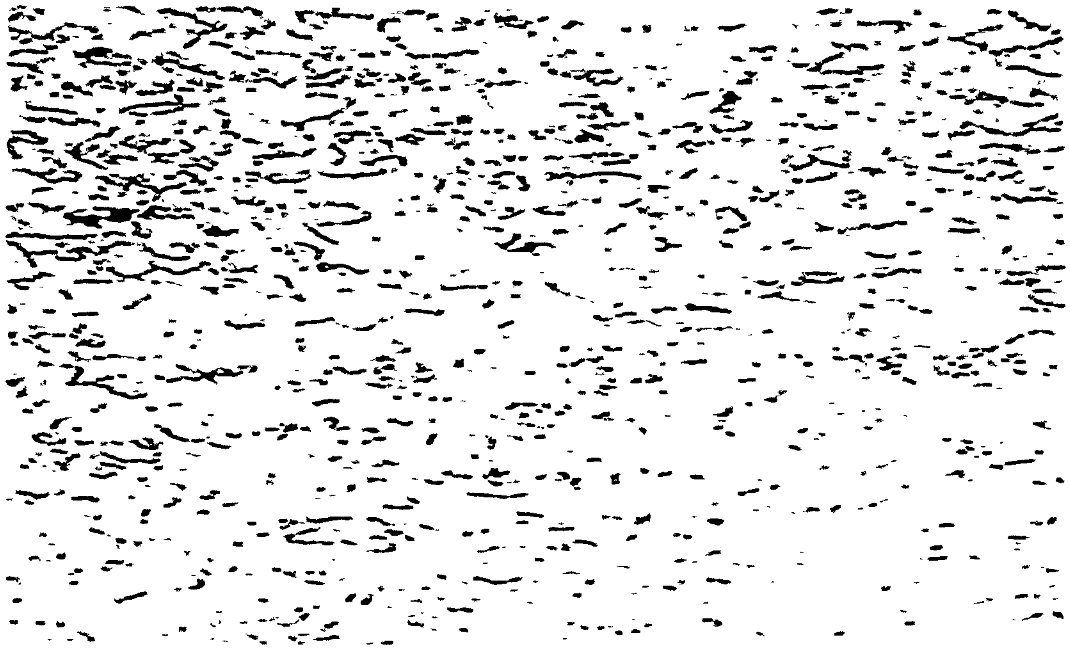


Figure 23 Neg. #3165-1967 Mag: 500X
Upper sidewall of headed piece showing cold-worked condition. Hardness R_b 90-97.

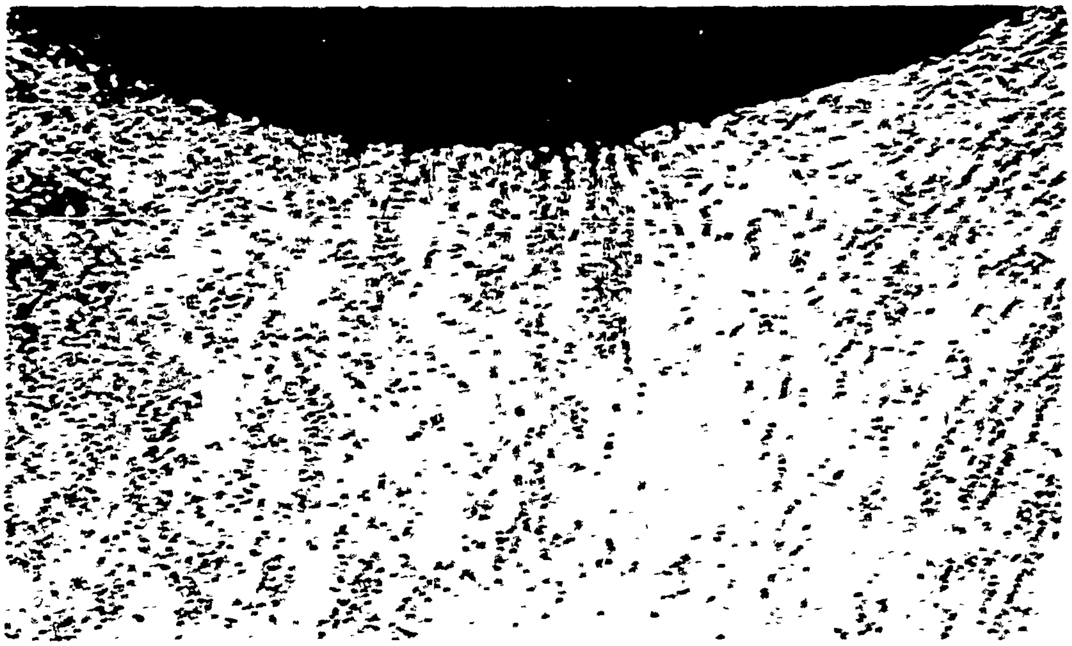


Figure 24 Neg. #3174-1967 Mag: 100X
Cold shuts in internal radius between sidewall and base of headed component.

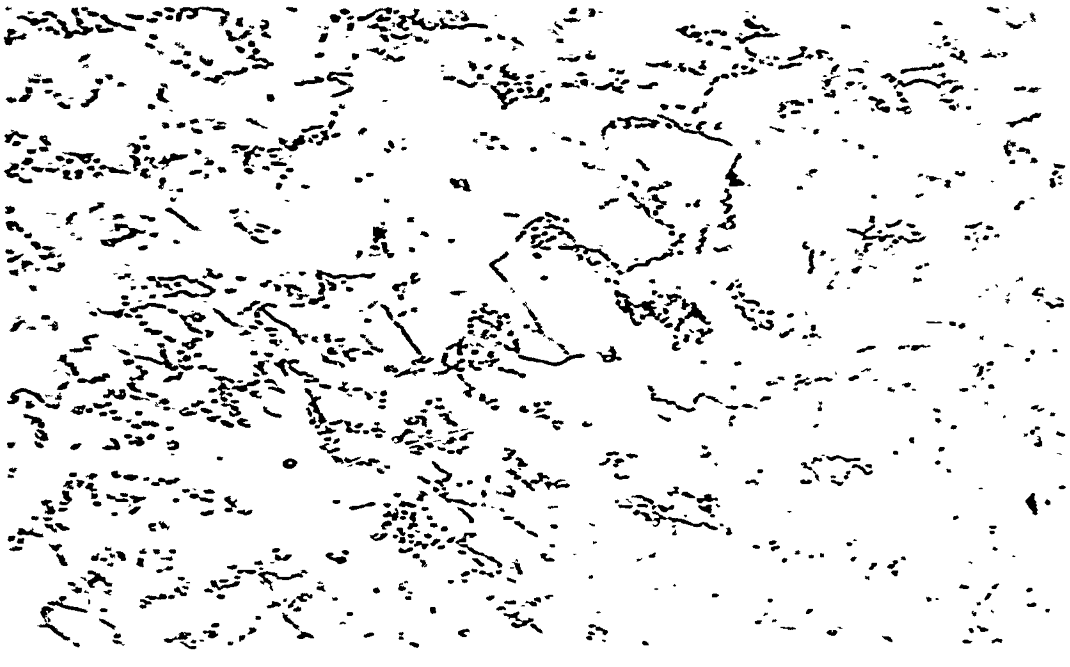


Figure 25 Neg. #3167-1967 Mag: 500X
Base of headed piece. Photomicrograph shows structure of relatively unworked area. Hardness R_b 87-96.

Figure 26 Neg. #2984-1967 Mag: 500X
Neck of hardened case showing completely untransformed fine-grained microstructure resulting from annealing of cold worked structure formed at tapering. Hardness R_b 89-100.

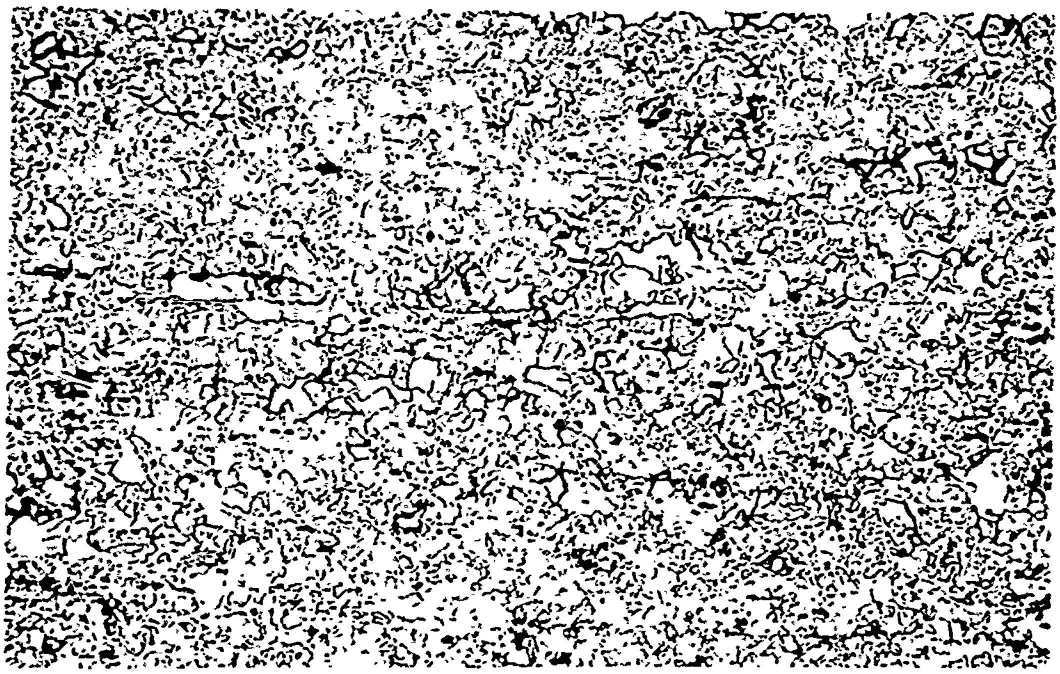


Figure 27 Neg. #2984-1967 Mag: 500X
Body-shoulder junction of hardened case showing untempered martensite and ferrite. Hardness R_c 47-54.

Figure 28 Neg. #2983-1967 Mag: 500X
Mid-sidewall region of hardened case showing untempered martensite. Hardness R_c 52-54.

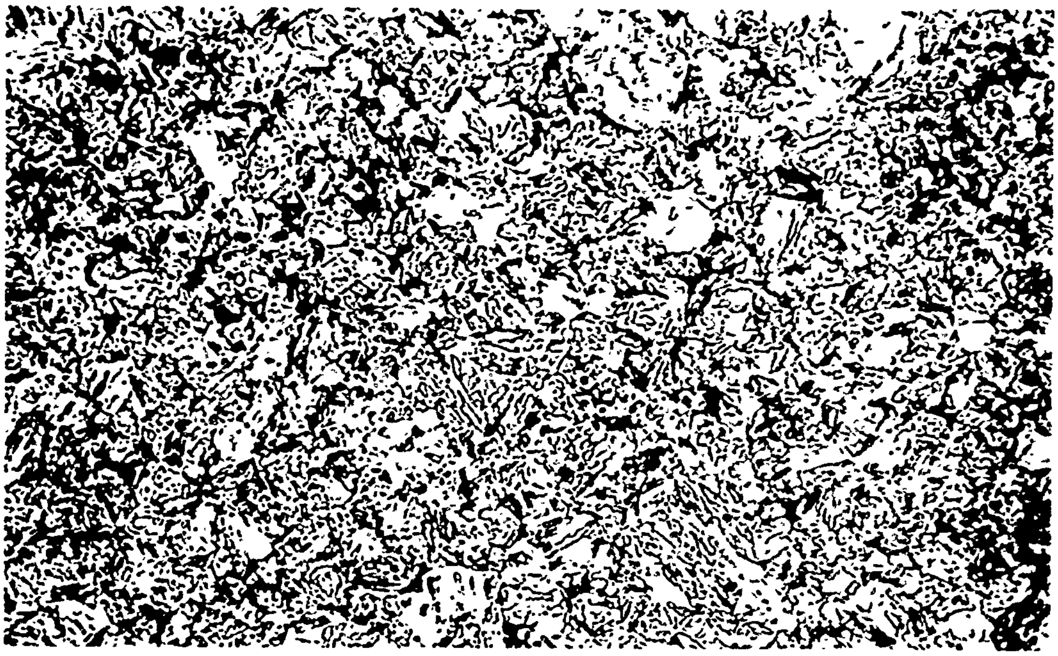


Figure 29 Neg. #2981-1967 Mag: 500X
Head of hardened case showing untempered martensite. Hardness R_c 49-50.

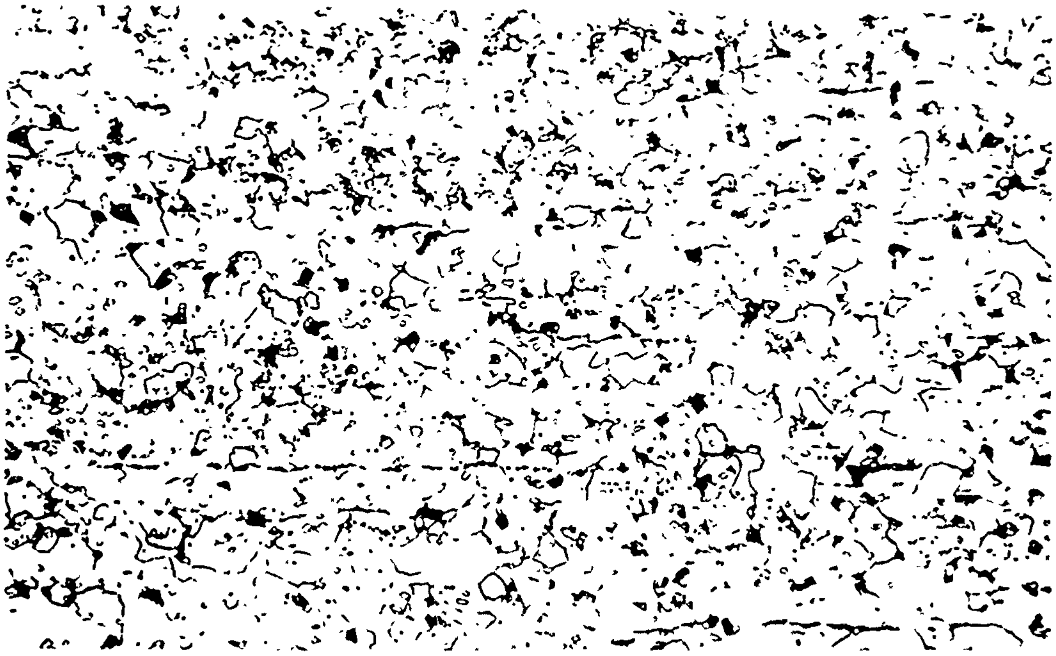


Figure 30 Neg. #2978-1967 Mag: 500X
Neck of tempered case. Microstructure contains ferrite along with spheroidal carbides carried over from the original strip material. Hardness R_b 64-65.

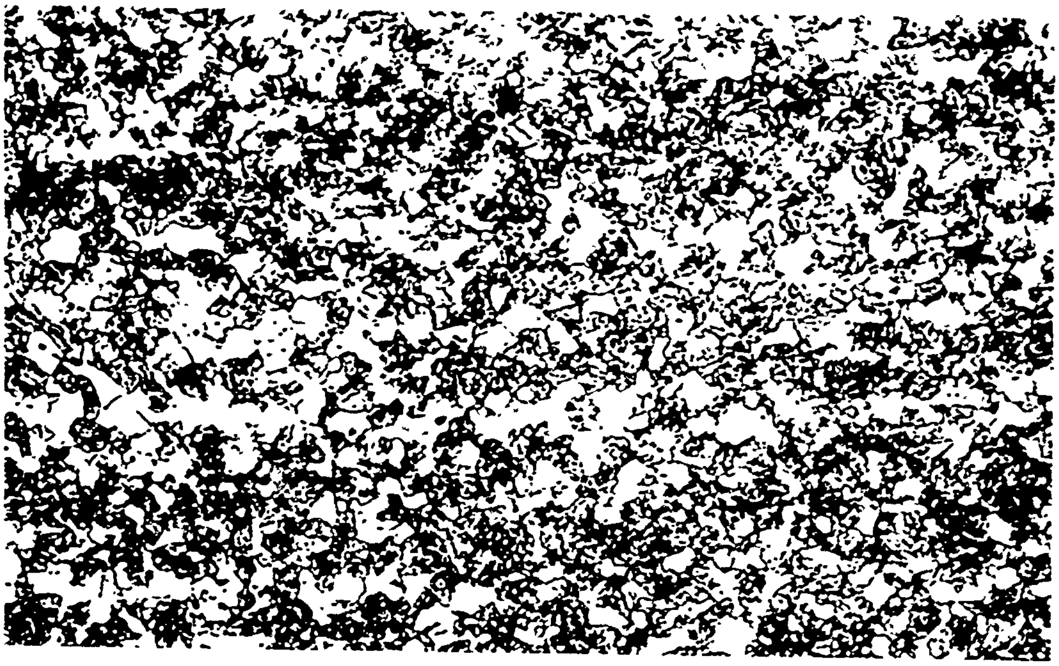


Figure 31 Neg. #2980-1967 Mag: 500X
Body-shoulder junction of tempered case showing tempered martensite and ferrite. Hardness R_b 83-95.

Figure 32 Neg. #2979-1967 Mag: 500X
Mid-sidewall region of tempered case showing tempered martensite. Hardness R_c 26.

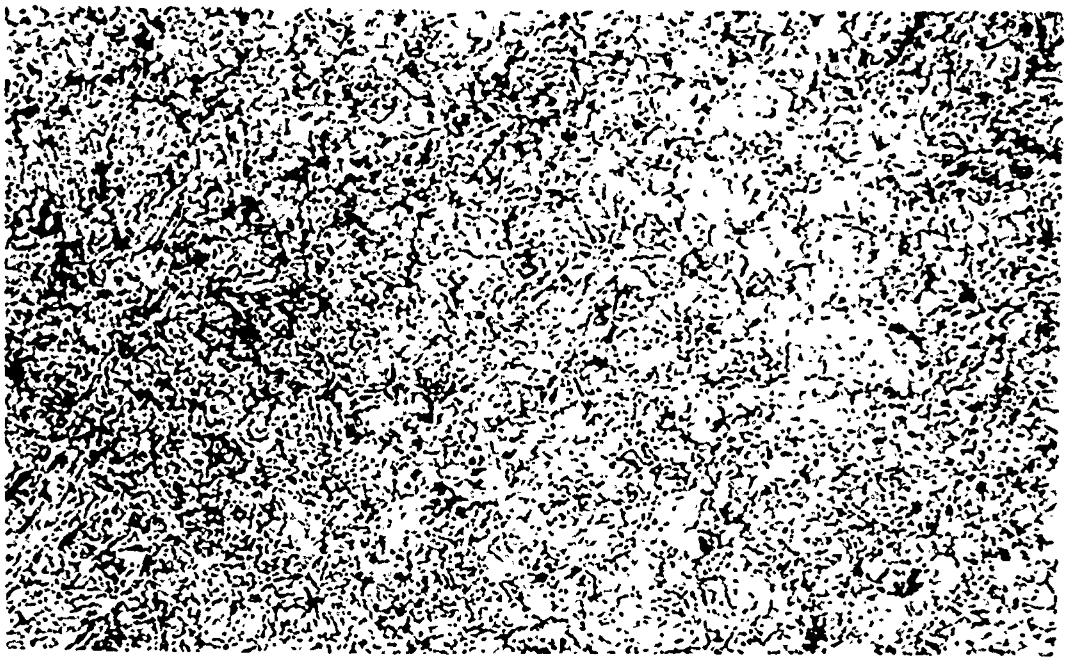
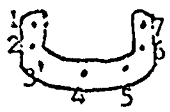


Figure 33 Neg. #2977-1967 Mag: 500X
Head of tempered case showing tempered martensite. Hardness R_c 24-26.

TABLE II - Hardness of 7.62mm Steel

Case Components for First Eight Lots (TMP 305)
(Number of pieces from which range was obtained is shown at head of column)

COMPONENT	CONDITION	LOCATION	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8
Cup	As drawn			1 pc.	1 pc.	3 pcs.	3 pcs.	4 pcs.	3 pcs.	3 pc
		1		97	90	91-92	94-96	94-95	92-94	93-95
		2		96	92	91-92	92-94	92-94	88-93	91-94
		3		81	70	73-79	71-72	74-77	71-76	71-74
		4		72	68	62-67	69-70	69-72	70-73	70-74
		5		82	74	66-84	70-72	71-74	70-74	69-75
		6		95	93	91-93	91-95	92-93	90-92	90-91
		7		95	90	90-92	94-95	93-95	92-93	91-94
Cup	Annealed		1 pc.	1 pc.	1 pc.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs
		1	66	68	65	66-68	65-66	62-67	62-63	59-64
		2	66	66	67	64-67	64	64-65	59-62	59-63
		3	60	66	68	67-72	60-68	62-70	60-62	51-52
		4	64	64	68	62-68	62-64	64	59-61	58-62
		5	70	68	72	69-71	61-71	65-69	58-64	52-53
		6	68	66	63	64-66	62-64	62-67	60-63	59
		7	68	68	68	64-69	64-65	65-66	61-63	62-64
1st Draw	As Drawn		1 pc.	1 pc.	1 pc.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs
		1	97	93	93	94-96	94-96	94-97	96-98	92-95
		2	95	93	94	93-95	92-95	93-96	95-98	93-94
		3	95	92	91	93-95	92-94	92-93	94-96	90-92
		4	70	66	75	69-75	65-71	69-75	65-71	67-71
		5	73	65	65	67-72	65-69	65-67	71-73	65-70



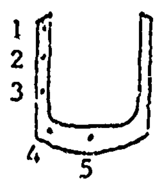


TABLE II (cont'd)

COMPONENT	CONDITION	LOCATION	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8
1st Draw	Annealed		1 pc.	1 pc.	3 pcs.	3 pcs.	4 pcs.	3 pcs.	3 pcs.	3 pcs.
		1	82	76	67-69	64-68	66-67	56-64	64-66	64-68
		2	77	72	66-67	63-67	64-66	57-65	63-64	55-68
		3	72	64	65-67	62-65	62-65	63-[illegible]	61-62	63-6[illegible]
		4	64	65	65-69	65-69	63-66	64-70	63-64	65-67
		5	62	65	64-69	64-66	62-66	62-67	62-64	63-65
2nd Draw	As Drawn	(From Base)	2 pcs.	1 pc.	2 pcs.	2 pcs.	3 pcs.	2 pcs.	3 pcs.	3 pcs.
		1-1/2 in.	96-97	96	94-96	96-97	94-98	97-99	90-97	97-101
		1-1/4	96-97	96	94-96	97-98	95-98	98-99	96-97	98-100
		1	96-97	96	95	97-99	94-96	99-100	96-97	98-100
		3/4	96-97	96	94-96	[illegible]-99	94-9[illegible]	98	96-97	97-99
		1/2	94-96	95	93-94	95-97	93-95	96-97	91-94	96-98
		1/4	92-94	93	88-90	92-96	90-94	93-94	90-93	92-95
		Base	83-84	70	79-84	84-87	74-78	77-79	74-79	74-7[illegible]
			76-78	70	78-81	75-82	69-74	7[illegible]-80	7[illegible]-79	70-72
2nd Draw	Annealed	(From Base)	1 pc.	1 pc.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.
		1-1/2 in.	64	67	60-66	61-66	62-66	69-71	60-68	65-68
		1-1/4	65	66	58-66	61-67	65-68	69-70	[illegible]7	65-67
		1	65	66	61-66	63-70	65-68	68-69	65-67	65-68
		3/4	64	65	62-67	64-69	65-68	68-69	65-69	63-64
		1/2	63	68	65-66	65-70	62-67	65-67	65-67	62-65
		1/4	59	65	60-64	62-65	60-66	64-65	64-67	62-65
		Base	67	64	67-70	68-71	65-69	55-64	68-72	60-71
			64	58	63-69	67-70	65-69	68-72	64-71	59-68

TABLE II (cont'd)

COMPONENT	CONDITION	LOCATION	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8
3rd Draw	As Drawn	(From Base)	3 pcs.	2 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	2 pcs.
		2-1/2 in.	76-79	77-80	79-80	76-80	80-84	-----	80-84	89-91
		2-1/4	93	81-94	92-93	80-93	94-96	-----	85-93	92-93
		2	93-94	87-93	92-93	89-92	93-95	96-97	92-94	93-94
		1-3/4	95-96	90-93	91-93	92-95	94-96	90-97	92-94	95-96
		1-1/2	93-96	90-94	91-94	92-95	94-97	94-97	93-94	94-95
		1-1/4	92-93	91-92	92-94	88-94	93-95	95-97	94	92-96
		1	92-93	90-91	92-93	83-92	92-95	93-95	93-96	97-98
		3/4	90-92	89-90	92-93	87-90	91-93	93-94	93-95	97-99
		1/2	80-91	89	90-91	86-89	88-92	91-92	91-92	95
		1/4	82-87	87	89-92	86-89	86-89	91-95	90-92	91-93
		Base	77-79	83-87	82-86	76-81	80-85	-----	80-84	83-86
			71	83	74-76	68-72	75-77	-----	78-81	73-79
32	Headed	A	85-89	84	86-90	87-89	83-87	95-98	91-93	87-92
		B	85-89	87	83-87	87-89	84-88	92-93	90-93	89-91
		C	91-94	91	88-94	92-94	89-92	96-97	94-95	93-95
		D	93-96	92	90-94	95-96	93-95	98-99	92-95	93-95
Case	Hardened	(From Base)	1 pc.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.	3 pcs.
		1.875 in.	91	97-98	82-91	89-100	94-95	94	92-94	95-97
		1.500 in.	98	33-42	37-47	47-54	27-46	31-43	47-52	51-54
		1.250 in.	29	39-53	51-52	53	49-51	49-50	52-54	53
		1.000 in.	43	39-53	49-52	52-54	46-49	51-53	52-53	52
		.750 in.	48	40-51	49-50	50-52	47-49	51-53	47-54	50-53
		.500 in.	51	46-49	49-50	49-50	47-49	49-52	36-52	42-51
		.250 in.	50	46-50	48-49	49-50	46-48	49-51	33-50	41-51
		A	48	48-51	47-50	49-50	47-49	50-51	47-50	49-52
		B	49	48-51	49-50	49-50	46-49	49-50	49-50	50-51
		C	46	45-49	49-50	49	44-46	51	49-50	49-51
		D	42	46-49	48-49	49	43-49	51	49	49-50

TABLE II (cont'd)

COMPONENT	CONDITION	LOCATION	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8
Case	Tempered	(From Base)	3 pcs.	3 pcs.	3 pcs.	3 pcs.	2 pcs.	4 pcs.	3 pcs.	4 pcs.
		1.875 in.	67-75	68-77	60-63	64-65	59	59-62	60-66	62-68
		1.500 in.	67-80	83-93	24-25	83-95	67-71	68-96	88-101	93-100
		1.250 in.	97-98	26-28	24-25	25-27	22-23	25-31	24-25	24-25
		1.000 in.	28-31	26-28	24-25	26	24	25-31	23-26	25-26
		.750 in.	31	26-28	24-25	26	23-24	25-31	25-26	25-26
		.500 in.	31	27-29	24-25	26	29	24-31	24-25	25-26
		.250 in.	29-32	27-28	25-26	26-27	24	26-31	25-26	26
		A	19-29	28	25-26	26	25-26	26-30	24-25	
		B	24-30	27-28	25-26	24-26	24	25-29	24-26	
		C	23-31	26-28	25-26	25-26	24	26-31	24-25	
		D	24-29	26-28	25-26	25-26	24	25-31	23-26	

PROCESSING

This section summarizes, with a brief description, each operation performed to produce heat treated steel cases according to TMP 305, at the conclusion of pilot production.

Procedures and equipment specified are current as of this writing. However, equipment and process improvement studies are continuing, particularly in the areas of extrusion, induction heat-treating, iron phosphating, and surface finishing. Efforts are being made to improve both the quality and efficiency of these operations, which at present have not been developed to the state necessary for continuous high-volume production.

Table III presents, in columnar form, a process comparison between the Frankford Arsenal heat treated steel-case process, the former Frankford Arsenal and LCAAP steel case process, used from 1954 to 1960, and the present brass-case process used by the GOCO plants. Identical operations, e.g., first draw, second draw, head, etc., are aligned horizontally.

TABLE III

COMPARISON OF PROCESS USED FOR HEAT TREATED STEEL 7.62MM CARTRIDGE CASES AS COMPARED TO FORMER STEEL AND PRESENT BRASS PROCESSES

Present Steel (FA Heat Treat)	Former Steel (FA and LCAAP)	Present Brass
1. Blank and Cup	1. Blank and Cup	1. Blank and Cup
2. Wash, Rust Preventive Rinse, and Dry	2. Wash, Rust Preventive Rinse, and Dry	2. Wash, Rinse, and Dry
3. Anneal	3. Anneal	3. Anneal
4. Phoscoat and Lube	4. Phoscoat and Lube	4. Pickle, Rinse, Neutralize and Rinse
5. First Draw	5. First Draw	5. First Draw
6. Wash, Rust Preventive Rinse, and Dry	6. Wash, Rust Preventive Rinse, and Dry	6. Wash, Rinse, and Dry
7. Anneal	7. Anneal	7. Anneal
8. Phoscoat and Lube	8. Phoscoat and Lube	8. Pickle, Rinse, Neutralize, and Rinse
		9. Wash, Rinse, and Dry
9. Second Draw	9. Second Draw	10. Second Draw
10. Wash, Rust Preventive Rinse, and Dry	10. Wash, Rust Preventive Rinse, and Dry	11. Wash, Rinse, and Dry
11. Anneal	11. Anneal	12. Anneal
12. Phoscoat and Lube	12. Phoscoat and Lube	13. Pickle, Rinse, Neutralize, and Rinse
		14. Wash, Rinse, and Dry
13. Third Draw	13. Third Draw	15. Third Draw
14. Wash, Rust Preventive Rinse, and Dry	14. Wash, Rust Preventive Rinse, and Dry	16. Wash, Rinse, and Dry
15. Trim	15. Trim	17. Trim
16. Sort	16. Sort	18. Sort
		19. Pocket
17. Head	17. Head	20. Head
18. Wash, Rust Preventive Rinse, and Dry	18. Wash, Rust Preventive Rinse, and Dry	21. Wash, Rinse, and Dry

TABLE III (Continued)

COMPARISON OF PROCESS USED FOR HEAT TREATED STEEL 7.62MM CARTRIDGE CASES AS COMPARED TO FORMER STEEL AND PRESENT BRASS PROCESSES

Present Steel (FA Heat Treat)	Former Steel (FA and LCAAP)	Present Brass
19. Head Turn	19. Head Turn	22. Head Turn
20. Vent and Deburr	20. Vent and Deburr	
	21. Body Anneal	23. Body Anneal
	22. Phosphate Coat	
21. Taper and Plug	23. Taper and Plug	24. Taper and Plug
22. Wash, Rust Preventive Rinse, and Dry	24. Wash, Rust Preventive Rinse, and Dry	25. Wash, Rinse, and Dry
23. Finish Trim	25. Finish Trim	26. Finish Trim
24. Wash, Rust Preventive Rinse, and Dry	26. Wash, Rust Preventive Rinse, and Dry	
25. Visual Inspect		
26. Harden	27. Harden	27. Stress Relieve
27. Wash, Rust Preventive Rinse, and Dry	28. Wash, Rust Preventive Rinse, and Dry	28. Pickle and Rinse
28. Temper	29. Temper	29. Neutralize and Lubricate
29. Iron Phosphate	30. Pickle, Rinse, Wash, Rust Preventive Rinse, and Dry	30. Dry
30. Varnish	31. Mouth Anneal	31. Mouth Anneal
31. Varnish Cure	32. Zinc Plate and Cronak Treat	
	33. Soap and Dry	
	34. Re-taper and Re-plug	
32. Visual Inspect	35. Visual Inspect	32. Visual Inspect

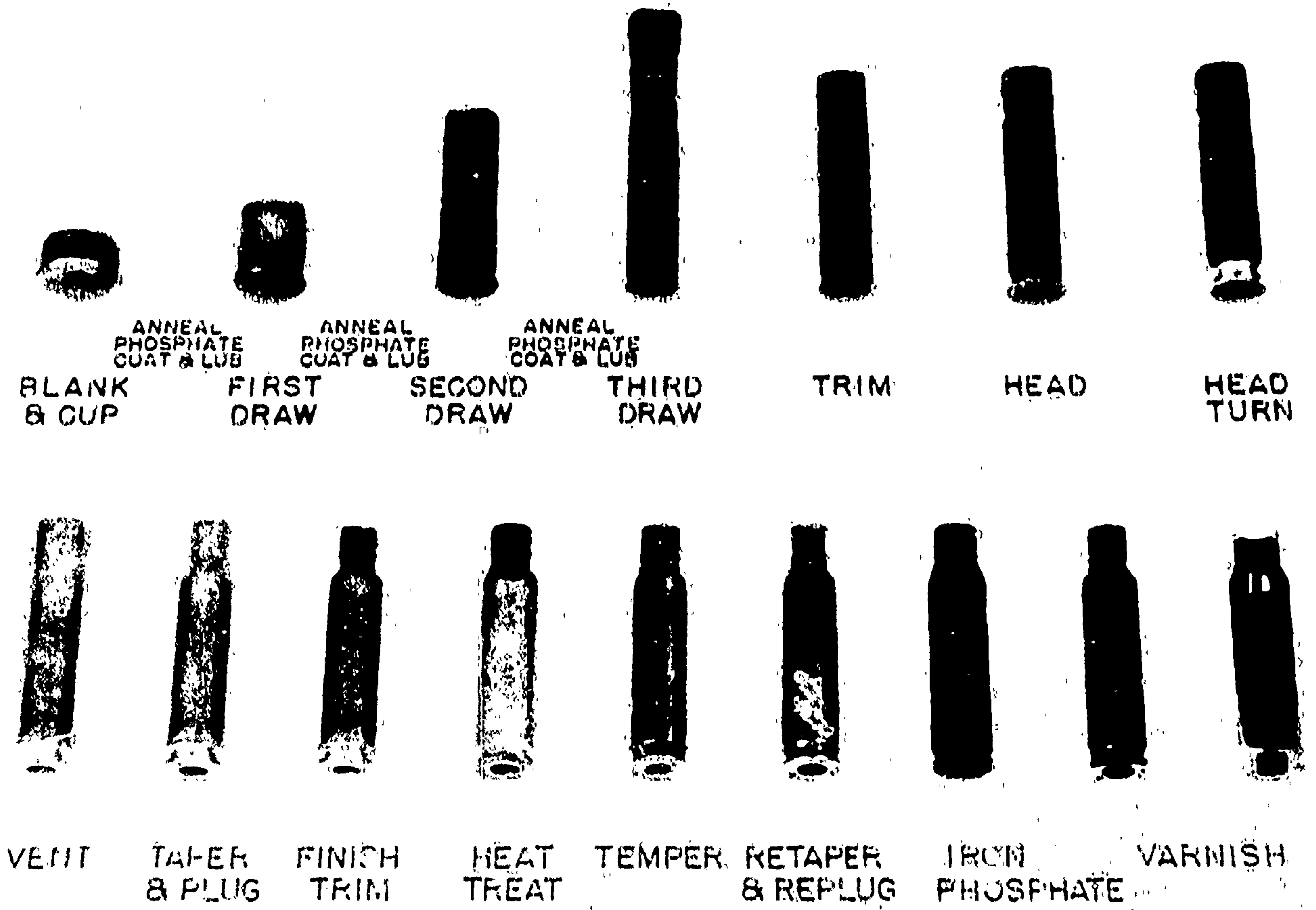


Figure 34. 7.62MM Steel Ctg. Case Heat Treat Process (TMP 301)

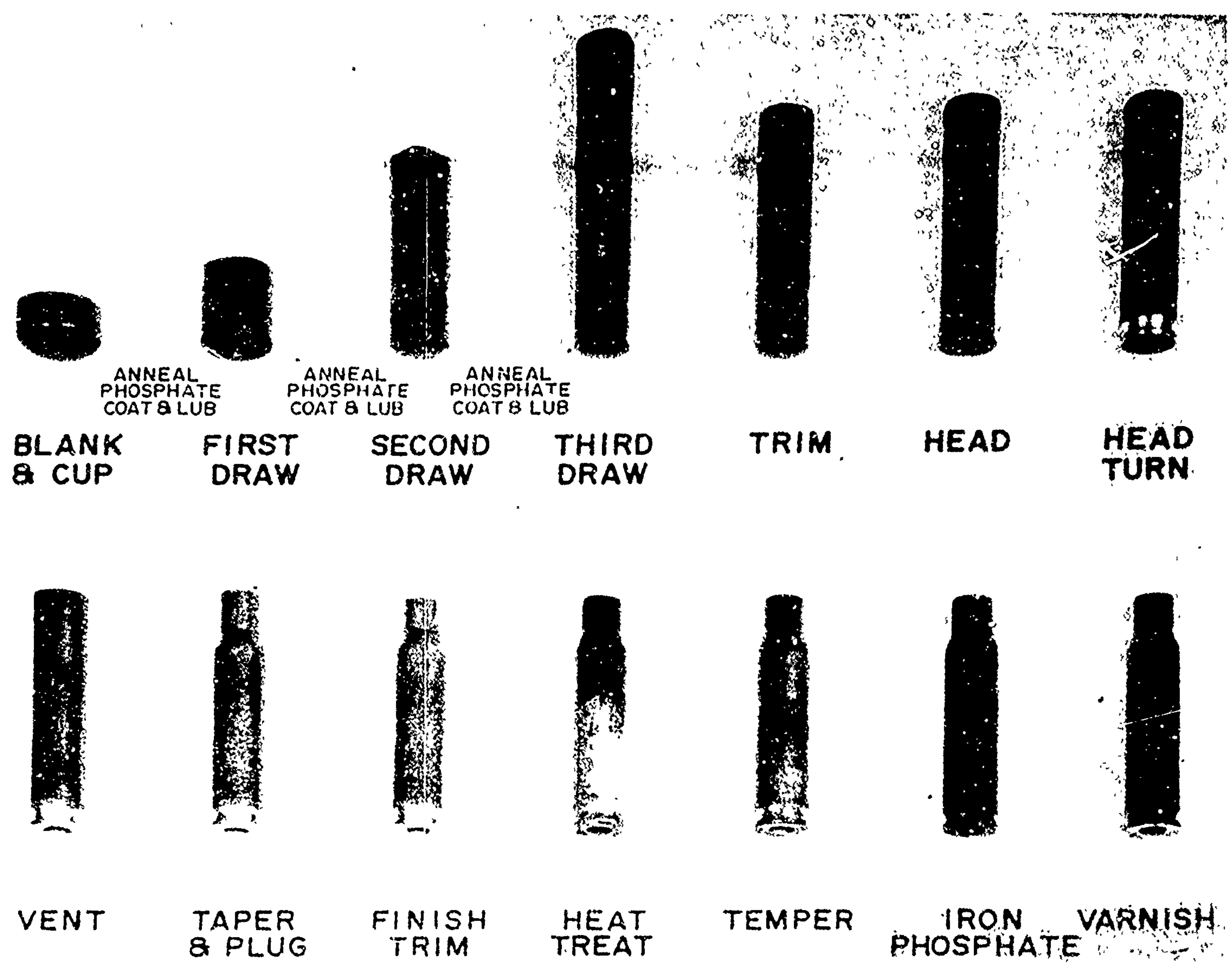
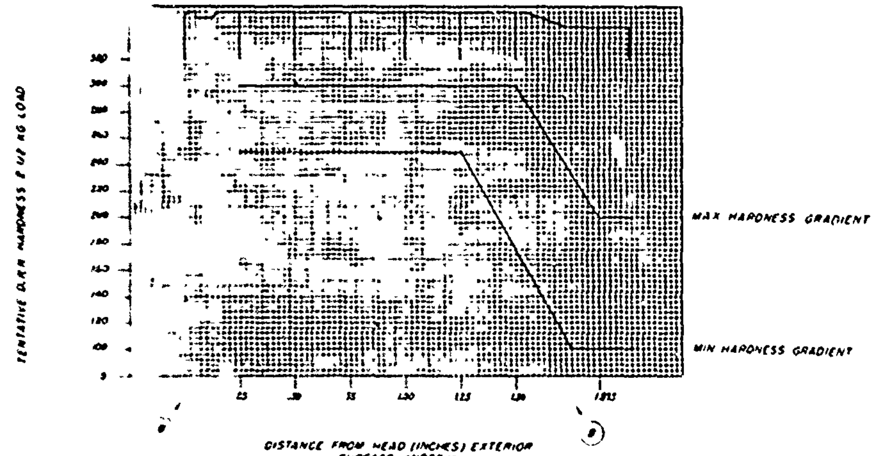


Figure 35. 7.62MM Steel Ctg. Case Heat Treat Process (TMP 305)

0X10542482

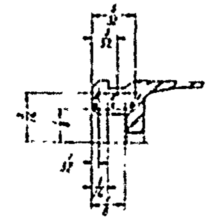
LTR	DESCRIPTION	DATE	APPROVED
A	ECO FSD # 2576		
B	11-21 SEE ECO FSD # 2551		



DISTANCE FROM HEAD (INCHES) EXTERIOR SURFACE (NOTE 1)

HARDNESS GRADIENT

SCALE 4/1

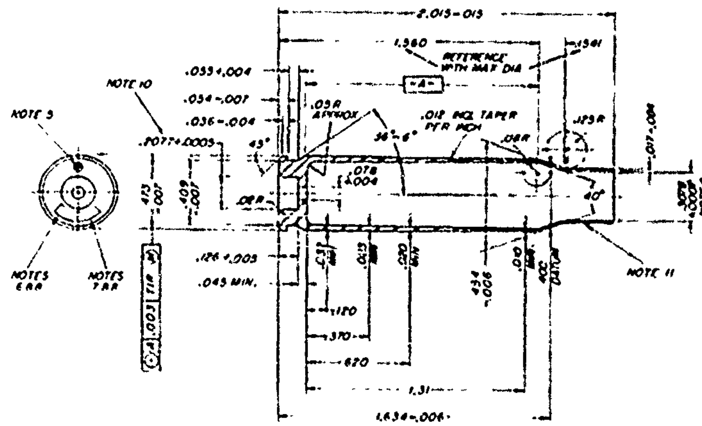


2 1/2 KG LOAD

HEAD AXIAL SECTION

MINIMUM 250 D.P.H.

SCALE 8/1



NOTES:

1 — HARDNESS GRADIENT
THE AVERAGE HARDNESS READINGS OF 10 FINISHED CARTRIDGE CASES AT EACH POSITION INDICATED SHALL FALL WITHIN THE RANGE FOR THAT POSITION DEFINED BY THE MAXIMUM AND MINIMUM HARDNESS GRADIENTS.

2 — DIMENSIONS INCLUDE PROTECTIVE FINISH

3 — DIMENSIONS GIVEN AT INTERSECTION OF LINES.

4 — DIMENSIONS AT PLUGGING OPERATION FOLLOWING TAPERING (INFORMATIONAL)

5 — NATO IDENTIFICATION MARK.

6 — STAMP INITIALS OF MANUFACTURER OR RECOGNIZED TRADE MARK

7 — STAMP LAST TWO FIGURES OF YEAR OF MANUFACTURE.

8 — STAMPING MUST BE LEGIBLE AND NOT ENCROACH ON THE PRIMER CRIMP OR HEAD BEVEL

9 — STANDARD FOR DIMENSIONING AND TOLERANCING SPEC MIL-STD-8 APPLIES

10 — DIMENSIONS AT HEADING OPERATION (INFORMATIONAL)

11 — AN INCLUDED TAPER NOT TO EXCEED .002 IS ALLOWABLE IN NECK

12 — MATERIAL:- STEEL, SPEC MIL-S-643 EXCEPT CARBON 0.22% TO 0.28%, SILICON 0.08% MAXIMUM; PHOSPHOROUS 0.029% MAXIMUM, SULPHUR 0.025% MAXIMUM. AVERAGE STRIP HARDNESS ROCKWELL R67 MAXIMUM; INDIVIDUAL READING ROCKWELL R70 MAXIMUM NO.5 TEMPER

13 — VARNISH, PHENOLIC, SPEC MIL-V-2275 TYPE III CLASS B, EXTERIOR THICKNESS PER SIDE .0002 TO .0004 COMPLETE COVERAGE INSIDE (NOT TO BE MEASURED)

14 — REFERENCE CUP DRAWING 8X10533793

PART No. X10542482

SEE NOTE 12

SEE NOTE 13

DATE NOVEMBER 9, 1967

U.S. ARMY FRANKFORD ARSENAL PHILADELPHIA, PA. 19137

CASE

D 19200 X10542482

Blank and Cup - Blanking and cupping were performed at Frankford Arsenal for the production of approximately 1,200,000 7.62MM steel cases processed under TMP 301 and TMP 305. An additional 40,000 cups were produced for fabrication into cold-worked 7.62MM steel cases. The cups used in both processes are identical.

The press used for blanking and cupping was a Bliss #6 double acting press, equipped with twin flywheels, operating at approximately 90 strokes/min. The die set used with this press contained five stations, allowing up to 5 cups to be formed by each press stroke. A single blank and cup die was used at each station for completely forming the cup; no sizing die was employed.

Blanking and cupping were accomplished using oiled steel strip as received from the steel supplier, without the benefit of a zinc phosphate coating. A trial run was performed by wiping DuPont "Vydax" on the strip before blanking, which appeared to lessen the force required for cupping, this approach was never fully exploited due to the volatility of the Vydax solvent. It was felt that installation of the required ventilation equipment would be too costly for the advantages gained.

Lubrication of the unphosphated strip proved to be a continuing problem to which a completely satisfactory solution was never found. Lubro 44, manufactured by G. Whitfield Richards Company, proved to be the most effective coolant solution tried, particularly when mixed with Lubri-Cool, manufactured by Lord Laboratories, Detroit, Mich., in the amount of 1 pound of Lubri-Cool to 55 gallons of Lubro 44 solution. In production, a coolant concentration of 1 part Lubro 44 to 1-1/2 parts water was found to be most satisfactory.

Coolant solution was applied to the tools using a pump-fed circulating system installed on the press. Streams of lubricant were directed onto the top of the stripper plate to achieve a puddling effect on the upper surface of the strip. In addition, streams of lubricant were also directed onto the underside of the strip, between the strip and the die block. With both of these methods however, coolant-flow into the dies ceases as the blanking punch brings the bottom surface of the strip into contact with the top surface of the die.

Due to the lack of a sizing die, injection of coolant thru a lube ring located below the blank and cup die was precluded. Consideration was given to the use of jets to direct lubricant upward into the die under pressure, but this was never attempted, due to the high viscosity of the coolant solution which requires the use of relatively large-diameter tubing to deliver a sufficient quantity of lubricant to the dies.

Various coatings were applied to the dies to reduce die pickup. Uncoated chrome-plated dies were able to be run for approximately 1,000 pieces before pickup reached an intolerable level. Rate of pickup was reduced with the use of manganese phosphated dies coated with Surf-Cote M1284, a matrix-bonded solid film lubricant manufactured by Hohman Plating and Manufacturing Company, Dayton, Ohio, use of this lubricant, qualified under MIL-L-8937, extended the interval between polishings of dies to approximately 8,000 pieces.

Die life, using a mixture of Lubro 44 and Lubri-Cool, with uncoated dies manufactured from FS-WI-10 or FS-WI-12 steel, is estimated to be approximately 25,000 pieces.

In an effort to determine the effects of zinc phosphate coating of the strip on blanking and cupping, 32 strips, each seven feet in length, were cut from a coil of steel and phosphate coated, these strips, containing approximately 4,000 pieces, were processed with comparative ease - most problems were eliminated, and tool life and production rate were increased. A process was also tried wherein partially-formed cups were made from unphosphated strips. The partial forming was performed with a blank and cup press without ironing, minimizing the friction between the cup and cupping die. The partially-formed cups were to be phosphated and lubed, and final-formed on a modified first-draw press. The process was never carried to completion due to tight pilot production scheduling, but results appeared promising for further development.

Wash and Rust Prevent - Following the blank and cup operation, the cups were washed to remove all traces of dirt and lubricant and thereby prevent the formation of any residue on the pieces during annealing. The rust preventive, consisting of a final rinse in potassium dichromate solution, retards rust formation during short periods of storage, and does not require removal prior to annealing.

Two methods were used to perform this operation, the first method, which is preferred, utilizes a Baird inclinable-barrel rotary washer. The pieces are introduced into the rotary barrel and rumbled without water (or with a slight amount, if cups contain dried lubricant) to remove any burrs produced at the blank and cup operation. The tumbling action produced by the baffles within the barrel removes the sharp edges from the cups and facilitates feeding to the first-draw press. The baffles in the rotary barrel of the washer are positioned such that rotation of the barrel in a clockwise direction permits drainage of the solution, rotation in a counterclockwise direction retains the solution, both cleaning and rust preventive solutions are added manually.

The second method of performing the wash-and-rust prevent operation utilizes a Niagara washer, this method lacks the rumbling action of the Baird washer. Several lots of cups were processed in this manner when the Baird washer was unavailable, but only as an emergency measure to maintain production schedules. No serious difficulties were encountered at first draw due to the presence of burrs on the cups. Two advantages of the Niagara washer are its drying section, which aids in rust prevention, and its relatively high speed.

The Niagara washer uses a rotating barrel with an augur to transfer the pieces from one solution to the next. The work is carried in the barrel above the solution surface, scoops built into the external surface of the barrel raise the solution into the barrel, immersing the pieces, the solution drains back into the holding reservoir thru holes in the barrel.

Anneal for First Draw - In all lots of heat treated cases, the cups were annealed in a Lindberg furnace prior to first draw. The purpose of this anneal is to reform the relatively-equiaxed grain structure present in the original steel strip, thereby increasing the ductility of the material and rendering it more suitable for additional forming.

TMP 301 required a hardness of R_B 48-55 on the outer sidewall 1/16" above the junction of base and sidewall (not 1/16" from inside base, as stated in the TMP), during processing, it was discovered that the Lindberg furnace, using the maximum heating and cooling times available, would not deliver this hardness - the minimum hardness obtainable was approximately R_B 59-62 at the specified position. Actually, this material was probably incapable of being annealed to R_B 48-55 by any conventional annealing cycle. Processing was satisfactory at this hardness, and TMP 305 subsequently specified a slightly higher hardness of R_B 65 max.

The furnace used for annealing was a 3-zone rotary retort-type furnace utilizing a carbon monoxide atmosphere to prevent oxidation of the components during heating and cooling. The temperature within the retort is controlled by zones. entrance. center. and discharge. During the annealing cycle. all zones were maintained at 1320°F. Due to heat loss thru the wall of the retort, the temperature of the pieces is maintained at 1290°F.

Phosphate Coat and Lubricate - Following annealing, the pieces were cleaned, pickled, zinc phosphated, and lubricated.

The machine used to perform this operation was a 2-section, rotary-cylinder type machine manufactured by N. Ransohoff, Inc. The various cleaning and coating solutions are maintained at the proper temperatures until ready for use, when they are pumped into the first section of the rotary cylinder containing the work. Upon completion of the cleaning and zinc phosphating stages, the work is transferred to the second section of the rotary cylinder, containing the lubricant solution, by reversal of the direction of rotation of the drum.

The first stage of the phosphate coat and lubricate operation consists of a cleaning treatment in alkaline solution to remove grease, oil and similar foreign matter. this is followed by a hot water rinse.

A pickle stage follows. using hot sulfuric acid solution to remove any oxidation and scale formed during annealing, and to etch the surface slightly to provide a surface to which the zinc phosphate will adhere. Pickling is followed by a cold-water rinse.

The zinc-phosphate coating is the last operation performed in the first section of the rotary drum. The coating used was Bonderite 160X, which is an adherent coating used to retain the lubricant film during subsequent forming operations. A cold-water rinse follows the zinc phosphate application.

Following phosphating, the pieces are transferred to the second section of the rotary drum where the lubricant coating is applied, the lubricating compound used was Bonderlube 235. The lubricant and the zinc phosphate must be purchased from the same manufacturer to assure compatibility between the two coatings.

First Draw - The first-draw operation was performed on the annealed cups using a Bliss #62 duplex press with a 5-inch stroke. producing four pieces per stroke (2 pieces each side). As with all drawing operations, two dies, top and bottom, were used to form the metal, these were used in conjunction with a guide ring and a stripper, but no lube ring was used.

Lubrication and tool cooling were accomplished using a single stream of lubricant per station, supplied by a circulating system and directed onto the punch and downward into the dies. No problems were encountered relative to lubrication and cooling, provided the zinc phosphate and lubricant films applied during the previous operation were satisfactory.

The wall thickness of 0.058 – 0.062" measured at 0.500" from inside base was changed during TMP 301 lot-4 processing, to 0.055 – 0.064" measured at 0.437" from inside base; this was done when it was found that accurate readings could not be obtained close to the mouth.

Wash, Rust Preventive Rinse, and Dry – The purpose of this operation is identical to that of the cleaning operation following blank and cup; however, the tumbling action produced by the Baird washer is neither necessary nor desired at this stage of manufacture; for this reason, the Niagara washer, used as the alternate following blank and cup, was used for this and all succeeding washing operations.

Anneal for Second Draw – The procedure and equipment used to perform this operation was identical to that used as anneal for first draw.

TMP 301 required a hardness of R_B 45–55 on the outer sidewall of the component, 1/16" above the junction of base and sidewall; however, as with the anneal for first draw, it was discovered that one annealing cycle in the Lindberg furnace, using the lowest speed available, would not yield the required degree of annealing. Thus, the maximum heating and cooling times (50 minutes each) were again used, yielding a final hardness of R_B 55–58. A maximum hardness of R_B 60 maximum was subsequently adopted for processing under TMP 305.

Phosphate Coat and Lubricate – This operation is identical to the phosphate coat and lubricate operation preceding first draw.

Second Draw – The second-draw operation was performed on a Bliss model 304 press with an 8-inch stroke utilizing a maximum of four stations to produce up to 4 pieces per stroke. In pilot production, however, only a single punch was used. The die set incorporated a guide ring, top die, lube ring, bottom die, and stripper.

Coolant solution was introduced at two locations: from a stream directed downward onto the punch and into the die set, and from the lube ring located between the top-and-bottom dies; it was found particularly important to maintain an unobstructed flow of coolant to the lube ring to prevent heating of the dies, and subsequent pickup and scratching of work.

The components were fed to the draw press by means of a rotary pin hopper, followed by an air-operated turnover to properly orient any piece fed upside down from the hopper. Flexible tubes were used to convey the pieces from the turnover to feed tracks located on the press; the pieces are pushed along the feed tracks by means of mechanically-operated fingers which cause each piece to drop by gravity into the guide ring prior to the downward stroke of the draw punch.

Wash, Rust Preventive Rinse, and Dry – This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Anneal for Third Draw – This operation is identical to the anneal for second draw. As with the anneals preceding first-and-second draws, the hardness requirement of R_B 45–55 imposed by TMP 201 could not be met using the Lindberg furnace; consequently, a maximum hardness of R_B 69 was specified in TMP 205.

Phosphate, Coat, and Lubricate – This operation is identical to the phosphate coat and lubricate operation preceding first draw.

Third Draw – The equipment used to perform the third (final) draw was essentially identical to that used for the second draw. The press used was again a Bliss model 201, but having an increased stroke of nine inches; the longer stroke was required so that the draw punch would clear the top of the second-draw component upon feeding, and so that the final draw component would be pushed completely thru the stripper on completion of the downward press stroke. The press used could accommodate a maximum of three punches, although a single punch was used for pilot production.

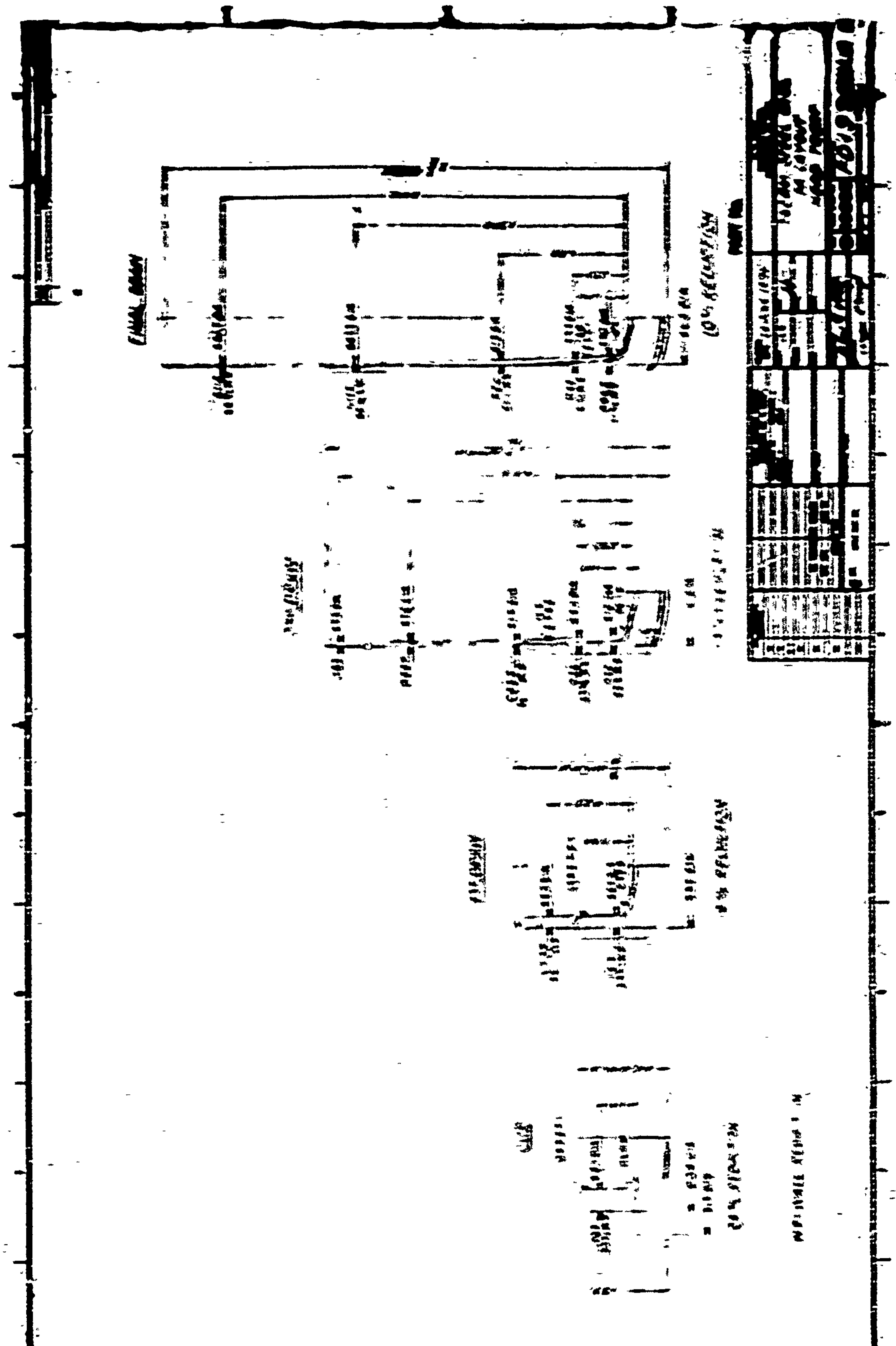
The draw punch used at final draw incorporated four tapers, which determined the inner sidewall shape of the finished cartridge case. Failure to blend two adjacent tapers properly was found to be the cause of circumferential ruptures encountered in proof testing; these ruptures were located at a distance of 1.250" from the inside base of the case — this corresponds to the junction point of two tapers on the final-draw punch.

Wash, Rust Preventive Rinse, and Dry – This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Trim – The machine used to perform this operation was a single-spindle horizontal trim machine, manufactured by Peters Engineering Company, employing both rotary and burring cutters; spindle speed used was 1740 rpm — cutter speed was 400 rpm. No lubricant was used at the trim operation; however, it was found in production that cutting-tool life was extended by incorporation of the wash, rust preventive rinse, and dry operation immediately preceding.

Sort – The purpose of the sort operation is to remove any scrap or mutilated pieces prior to the heading operation. The trimmed pieces are fed from a hopper onto a moving conveyor belt where the operator performs a 100% visual inspection, manually picking out defectives.

Head and Identify – At this operation the head, headstamp, and inside-base configuration are formed. All processing of heat treated cases utilized this "one shot" heading technique, eliminating the necessity of performing separate bump and/or pocket operations.



The machine used for heading was a 65-ton horizontal crank-and-toggle press manufactured by Jarecki Machine Company, having a crank stroke of 8 1/2" (pocket punch), and a toggle stroke of 7 7/8" (eject stem). Feed was by means of a pin hopper; an automatic knockoff device, actuated by a limit switch on the feed mechanism, stopped the press in the event of a feed stoppage — this was necessary to prevent contact between the heading punch and eject stem when no work was present in the die.

A 2-piece heading punch was used throughout the program because of difficulties encountered in obtaining 1-piece punches, this method was found satisfactory, although it produced a slight burr at the junction of primer pocket and head surface — this burr was subsequently removed by the addition of a deburring station at the venting operation. For future production, it is recommended that 1-piece heading punch PT 1035J be utilized, with the pilot size modified to that shown on drawing SKFSA 11277 (0.2051 – .005" diameter).

<u>Wash, Rust Preventive Rinse, and Dry</u> – This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

<u>Head Turn</u> – The machine used to perform this operation was a single-spindle horizontal head-turn machine manufactured by Standard Knapp, spindle speed of 2270 rpm, and machine speed of 40 rpm (40 pieces per minute) were found to be most satisfactory in production.

Tool life and breakage continued to be a problem, although improvements resulted from adoption of the 40 rpm machine speed and a change to carbide tooling. Tool cooling and lubrication were accomplished by means of an atomizer dispensing a mist of lubricant directly onto the cutting tool. Lubricant cannot be applied prior to the head-turn operation as this causes slippage between the component and the collet used to grip the piece.

Due to the difficulties encountered at the head-turn operation, it is recommended that any future developmental work on head turning of steel cases be performed on a Black Rock Universal trim machine, this machine, having variable-speed motors and adjustable feed, is more versatile where developmental work is required to determine optimum speeds and feeds.

<u>Vent and Deburr</u> – The vent-and-deburr operation for the steel case was separated from the prime operation in order that the varnish applied to the finished case would completely cover the case, including the venthole. Venting at this stage also results in more satisfactory quenching at the hardening operation.

The machine used was a crank-and-rocker, vertical, straight-line, underdrive primer-insert machine manufactured by Waterbury Farrel Foundry and Machine Company, the machine was altered by removal of stations, in order that only the burr, vent, and no-vent detect functions would be performed.

Various automatic knockoff devices were incorporated into the machine setup, these were as follows:

a. At the burr station a knockoff device was actuated in the event that a case failed to feed into the machine.

b. At both the first-and-second no-vent detect stations, a knockoff device was actuated in the event that a case was produced with no venthole, an eccentric venthole, or with foreign matter in the pocket.

As stated in the description of the head operation, the burr station incorporated in the vent and deburr operation may be eliminated when a 1-piece heading punch is used. In the event that a 1-piece heading punch is used in future production, it is recommended that a horizontal crank, single-punch press manufactured by Derbyshire Machine Company, be utilized to perform the vent operation. The Derbyshire machine operates faster but is unable to accommodate both the venting punch and the deburring punch.

<u>Taper and Plug</u> - The taper-and-plug operation was performed on a vertical double-action crank press, Bliss model 162. The press utilizes a rotary indexing table to feed the pieces to each successive stage of the operation.

TMP 301 and TMP 305 specified a "one shot" taper in which only one tapering station was used — thus, the stages in the operation consisted of mouth iron, taper, and plug. The work produced by this method was satisfactory, although constant surveillance and frequent machine adjustment were required to maintain dimensional quality and freedom from physical defects.

During processing of TMP 305, a first-taper station was added which coned the mouth of the untapered case prior to final tapering, this change improved the quality of work and reduced press downtime.

The mouth-ironing operation was not used for a portion of the production, particularly when the work coming to the taper-and-plug operation contained no dents in the mouth area, however, it is recommended, due to the seriousness of neck-and-shoulder area dents and folds, that the mouth-ironing operation be utilized.

With the processing of lot 6a, under TMP 301, the body anneal, and phosphate coat and lubricate operations preceding taper and plug had been eliminated. Processing of lots 6a thru 6d constituted efforts to eliminate the wrinkling which was occurring at the taper-and-plug operation. Proof testing of lot 6d, indicating success, showed that the body anneal had produced a soft area below the shoulder in the upper sidewall which did not possess sufficient strength to resist the tapering forces being applied to the shoulder and neck, and was subsequently wrinkling, this was observed by removing the varnish coat from the upper sidewall of a split case after firing — the wrinkles then became readily visible. This same method was used as a check on processing at the taper-and-plug operation to assure freedom from folds and wrinkles in the neck, shoulder, and upper-body areas. The case to be examined was rotated in a lapping head while fine emery cloth was held against the areas to be examined — in this manner, indentations were indicated by unburnished areas.

It was discovered that the cleanest possible outside surface prior to tapering produced the most satisfactory tapered case, it was for this reason that the phosphate coat and lubricate operation was eliminated. The only lubricant used was a light film of mineral cutting oil applied at a lubrication station on the press preceding the first taper station. A drop of cutting oil entrapped between the tapering dies and case will produce a dent, as will a buildup of dirt or solid-film lubricant -- therefore, the amount of oil applied at the lubrication station should be limited to the minimum necessary to prevent die heating, and subsequent pickup and scratching of work.

<u>Wash, Rust Preventive Rinse, and Dry</u> - This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

<u>Finish Trim</u> - The finish-trim operation was the last forming operation performed in the case manufacturing process. The machine used was a single-spindle vertical trim machine manufactured by Fidelity Machine Company, having an operating speed of 107 rpm, and a cutter spindle speed of 1135 rpm.

Carbide cutters, identical to those used for 7.62MM brass case processing, were used throughout -- tool life was satisfactory for the quantities of cases produced, although cutter-design changes are recommended for processing of production quantities of steel cases. A smaller amount of metal is removed from the steel case than is removed from the brass case, thus extending tool life slightly.

In using the Fidelity machine to perform the finish-trim operation, it was found particularly important to prevent feed stoppages which would allow the flexible feed tube to become empty. When the tube became empty, the last piece fed to the machine, lacking the downward force produced by the weight of the pieces in the tube, tended to bounce and be held by the case support at a position abnormally close to the head of the case, causing a short-trim length.

<u>Wash, Rust Preventive Rinse, and Dry</u> - This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

<u>Visual Inspect - 100%</u> - Upon completion of forming and heat-treating operations, all cases were visually inspected 100% for the defects listed in the Procedure for Control of Quality (see appendix).

This inspection is virtually identical to the visual-inspect operation following varnish cure.

It was <u>found</u> that a single finished-case inspection was not sufficient to cull out all defectives, particularly those having folds and wrinkles occurring in the neck and shoulder. Many of these defects are obscured by the varnish coating.

TMP 303 lists this operation following tempering. However, the color of the cases following tempering obscured the defects due to loss of surface reflectivity. Consequently, visual inspection was later performed prior to tempering.

Quench Harden – Hardness of the finished case is achieved by means of an induction-heating cycle followed by a mouth-down oriented quench in caustic soda solution. High-frequency alternating current is supplied to the induction coil by means of a 10,000 Hz motor-generator set.

Cases to be hardened are fed from four hoppers thru flexible tubes to an inverting mechanism. An ejection device causes any cases fed to the inverter upside down to be rejected. The inverter, by means of a "ferris wheel", inverts the cases before transferring them mouth-down to an indexing table. The cases are held vertically in transite case carriers attached to the indexing table as they are passed transversely between the coils of the heating fixture by the rotation of the table.

The magnetic field produced by the induction coil lifts the cases slightly in the transite holders until they are stopped by a permanently-located strip of nonmagnetic material — thus positioned, the head and sidewall of the case are located within the alternating field, which raises the temperature to approximately 1700°F, for 11 seconds. The neck and shoulder of the case protrude below the coil and are heated only by the weaker field existing below the coil and by conduction from the hotter portion of the case — thus positioned, the head and sidewall of the case are located within the alternating formation to martensite, resulting in lower hardnesses in these areas (see "Metallurgy" section of this report).

Following the heating cycle, a retainer plate under the transite carriers is retracted and the cases, assisted by an airblast, fall mouth-downward into four tubes leading to the caustic quench solution, a wire-mesh conveyor then transfers the quenched cases from the quench solution into a truck for further processing.

Two separate indexing-table drives, both air-operated, were tried during pilot production of steel cases -- both were operated by a pneumatic cylinder operating thru a Geneva-stage-type linkage located beneath the indexing table, problems were encountered with both of these drives. Heat from the cartridge cases and the effect of chemicals in the quench solution caused lubricants to become ineffective, materials to corrode, and friction to increase, resulting in erratic operation and inaccurate positioning of the indexing table.

At the present time, an electric drive is being installed but has not as yet been tested. Drive is by means of an electric motor and a positive-stop transmission located above the indexing table, away from heat and chemicals. Motor speed is continuously variable by means of an SCR circuit. A magnetic clutch connects the electric motor to the transmission, providing instant start-and-stop capability.

A simulated firing test was performed in which 80 steel cases improperly heat treated head down, rather than mouth down, were assembled into cartridges and fired in an M73 machinegun. Despite efforts and controls to assure proper positioning, it was recognized that improper heat treatment such as this was a possibility. Case casualties included two stoppages, 10 blown primers, 70 large primer leaks, and two small I-splits, all of which were attributed to the soft heads, and excessively hard mouths and necks which resulted.

Due to the extreme hardness produced by the quench-harden operation, it is inadvisable to store the cases longer than necessary following this operation. Recommended time period for storage prior to the temper operation is two hours maximum. During a single-shift production schedule, as followed in pilot production, it was found difficult to perform the quench harden; wash, rust preventive rinse, and dry; and temper operations within one 8-hour shift. Thus, the following time schedule was substituted: all cases quench hardened before noon were tempered the same day; all cases quench hardened in the afternoon were tempered before noon the following day.

Wash, Rust Preventive Rinse, and Dry - This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Temper - The tempering operation is performed on a batch basis in an electric furnace having a recirculating air atmosphere. The interior of the furnace is raised to 800°F, and the work is maintained at that temperature for 75 minutes.

During development, several different tempering times and temperatures were tried before the above was adopted. TMP 301 lot 6d was tempered at 800°F for 75 minutes. TMP 305 lots 2-5 and 7-8 were tempered at 850°F for 75 minutes in order that the sidewall hardness could be reduced to coincide with the desired gradient. With processing of TMP 305 lot 9, tempering was again performed at 800°F, for 75 minutes, since the case mouth was becoming excessively soft. Final case hardness is determined both by the quench-harden operation, and by the temper operation. Thus, adjustments in tempering time and/or temperature may be required to meet the recommended finished-case hardness gradient, depending on lot-to-lot variations in hardened-and-quenched case hardness.

Iron Phosphate - The iron phosphating operation, consisting of several separate operations utilizing a series of tanks, was performed to clean and etch the cases and provide a base upon which to apply the varnish coating.

The pieces were placed in a rotating perforated nylon barrel suspended from a hoist, such that the barrel could be immersed in each solution tank for the required time interval and then withdrawn.

It is particularly important that utmost care be taken to assure satisfactory results at this stage of processing due to the need for adequate corrosion protection of the finished case. poor iron phosphate application precludes proper varnishing. Specification TT-C-00490a (Army MR) should be consulted for test procedures.

The appearance of the iron phosphate coating deposits must be continuous, and the coating must be uniform in texture and evenly deposited. The coating must be golden yellow to purple in color. There shall be no smut, powder, corrosion products, or white stains due to dried phosphating solutions.

Varnish - Varnishing was performed using a centrifuge-type varnishing machine, manufactured by Ronci. In operation, the iron-phosphated cases are placed in varnishing ranks which are inserted one at a time into the varnish machine. The cases are first immersed in varnish for approximately one minute, and are then spun for approximately one minute to remove excess varnish. The varnish removed drains back to the varnish reservoir in the machine.

The phenolic varnish used is purchased in accordance with MIL-V-12276, Type III, Class B. Varnish viscosity at room temperature must be 26 to 30 seconds, Zahn #2 cup, for proper application.

Because of the amount of time and labor involved in applying the varnish using the Ronci machine, a large-capacity production type machine was designed and procured in 1960 to perform the varnishing and curing operations on a continuous basis. The machine utilized a series of pins which were loaded manually and conveyed the cases through varnish, drain, cure, and eject stations. Provisions were also made for stripping the excess varnish from the conveyor pins prior to reloading.

The machine was tested using sample cases. Varnish application was satisfactory, although stripping of cured varnish from the conveyor pins could not be accomplished satisfactorily. Use of the machine was consequently discontinued.

Varnish Cure - The varnished cases are allowed to dry following varnishing until the varnish has air dried to some degree. The racked cases are then wheeled into a Genrich oven where they are cured at 375°F to 400°F (metal temperature) for a minimum of 20 minutes. Total time in the oven is 30 to 45 minutes, including the time required for the oven to reach operating temperature.

The color of the cured cases was used as a general check on the varnish curing operation. Properly-cured cases were uniformly dark green in appearance, a gray appearance indicated incomplete curing, dark brown indicated excessively high-curing temperature -- both of these latter conditions should be avoided.

The following test was devised to check for complete curing. Three cases from the batch to be tested were immersed in acetone purchased in accordance with Federal Specification O-A-51, for a period of five minutes. On removal from the acetone, the sample cases were rubbed vigorously with the thumb, hand, or suitable wiping material, and visually inspected for evidence of lifting, blistering, or softening of the varnish. In the event that the sample cases failed to pass the acetone immersion test, the group of cases was returned to the oven for additional curing.

Varnish thickness, as specified by drawing DX 10542482, is 0.0002 to 0.0004". Varnish thickness is measured in accordance with Specification TT-C-00490 (Army MR). Salt spray tests were performed on all lots of heat treated cases. The test method was as prescribed by Federal Test Method Standard 141a, Method 6061. However, reported results of salt spray testing conveyed little useful data, primarily due to lack of adequate direction needed for meaningful evaluation of results. To evaluate test results properly and to assure reproducibility in the future, the following guidance is offered:

a. Twenty cartridges are exposed to 20% salt spray for 24 hours.

b. The specimens shall be positioned in the chamber at an angle of 15° from the vertical with the bullet uppermost.

c. The significant surface shall be that surface lying 60° to either side of the vertical, i.e., the upper 1/3 of the circumference.

d. The specimens shall not be scored as stated in para 3.4.2 of method 6061 of Federal Test Method Standard No. 141.

e. The specimens shall be rinsed and dried to remove corrosion products and salt, as stated in para 4.1 of method 6061, before examination.

f. After preparation for examination, significant surfaces of the cartridge shall show no signs of corrosion, pitting, or rusting. However, rust within 1/32" of any edges, or on any surface not requiring coating shall be permitted.

Visual Inspect - 100% - This inspection is similar to the 100% visual-inspect operation preceding quench hardening. At this inspection, both forming and coating defects are culled out. Some types of defects become more readily visible at this operation, due to the increased reflectivity of the case surface.

It was found difficult to detect folds, draw scratches, dents, and wrinkles with simply a visual inspection as used with small caliber brass cases. The seriousness of these defects is increased with the use of steel -- it thus becomes particularly important that all of these defectives be removed. It is important that inspectors be trained in advance to recognize and separate cases containing even the slightest defects, that lighting be sufficient and that magnifiers be of adequate size and power. Paddle hoppers of inspection machines and all other machines through which varnished cases pass should be kept as clean as possible, it was noted that inspection-machine paddle hoppers which contained a build up of dust and nonadherent zinc phosphate from the inspection operation preceding quench harden, severely scratched the varnish coating on the cases.

Prime - Primer insertion was performed using a Waterbury Farrel primer insert machine identical to that used for the vent and deburr operation, with the vent and deburr stations removed. The two no-vent detect stations were used at both the vent and deburr, and prime operations, while these stations were not entirely necessary at this stage of processing, they were included to eliminate the possibility of occurrence of this serious defect. In the event that the Derbyshire venting machine, not having no-vent detect stations is used, these stations must be operational at priming.

At the priming operation, (using the Waterbury Farrel vent-and-deburr press), the following functions are performed:

a. No-case detect - an automatic knockoff device is actuated when a case is omitted, stopping the machine.

b. Spread mouth - the mouth and neck of the case are straightened to facilitate bullet insertion.

c. No-vent detect No. 1 and 2 - an automatic knockoff device is actuated when a missing venthole or foreign matter is detected in the pocket at either of these two stations.

d. Insert and seat primer - the primer, fed in by a conveyor, is inserted into the case to the proper depth.

e. Inverted and no-primer detect - in case of an inverted or missing primer, an escapement is automatically opened to allow the case to drop into a reject container.

f. Crimp - the metal immediately surrounding the primer is circularly crimped to retain the primer in the pocket.

g. Waterproof mouth and primer - waterproofing compound is applied to the case mouth by means of a plunger, and to the space between the primer and the pocket. Before cartridge assembly, the mouth waterproofing should be allowed to dry for a period of not less that two hours, nor greater than two days. This time limit was imposed as a result of vacuum tests which indicated a high incidence of waterproofing failures caused by insufficient or excessive drying periods.

PROOF TESTING

Simulated acceptance testing was performed on all lots of cartridges produced under TMP 305. Selected tests were performed on TMP 301 lots 4, 6A, and 6D. Testing was performed according to AMCR 715-505 "Ammunition Ballistic Acceptance Test Methods, Vol 3: Test Procedures for 7.62MM Cartridges" dated Feb 64. Specifications MIL-C-46281C (MU), dated 1 May 65, and MIL-C-46931B (MU), dated 1 May 65 were used for evaluation of tracer and ball ammunition, respectively.

Briefly, the acceptance tests fired and the requirements of the tests are as follows:

Accuracy - mean radii of 90 cartridges fired at ambient temperature and at 600-yard range shall not exceed 5.0 inches for ball ammunition packed in cartons or clips, 7.5 inches for ball ammunition packed in links, or 15.0 inches for tracer ammunition.

Velocity - average velocity of 20 cartridges conditioned at 68° - 72° F, shall be 2750 ± 30 fps. Average velocity of 20 cartridges subjected to high or low temperatures shall not vary from the average velocity of the same lot conditioned at 68° - 72° F, by more than +250 fps, nor more than -150 fps.

Chamber Pressure - average chamber pressure of 20 cartridges conditioned at 68° - 72° F, shall not exceed 50,000 psi. Average chamber pressure of 20 cartridges subjected to high or low temperatures shall not exceed 55,000 psi, nor exceed the average chamber pressure of the same lot conditioned at 68° - 72° F, by more than +7,500 psi, nor more than -15,000 psi.

Port Pressure - average port pressure of 20 cartridges conditioned at 68° - 72° F, shall be 12,500 ± 2,000 psi.

Action Time - average action time of 50 cartridges fired at 70° ± 2° F, shall not exceed 4 milliseconds.

Tracer - 95% of a sample of 200 tracer cartridges fired at ambient temperature must function according to specification.

Vacuum - 50 cartridges are immersed in water in a container which is evacuated to 7-1/2 psi below atmospheric pressure. Data given in table V lists the number of leaking cartridges of a sample of 50, in the event that a re-test was performed, the table lists the number of leaking cartridges of a sample of 100.

Bullet Pull - the force required to extract the bullet from the case shall not be less than 60 pounds. Averages listed are for 10 cartridges.

Function and Casualty - quantities of cartridges fired in each weapon, at each temperature, are listed below:

	Temp (° F)			
Weapon	+70	+125	+160	-65
M60	300	50	50	100
M52	300	50	50	100
M14	120	40	40	80
G3	120	40	40	80
LAR	120	40	40	80
L1A1	120	40	40	80
M73	1000	50	50	100

Firing in the M73 machinegun is not required by specification and was performed for information only.

Permissible quantities of the defects shown in the tables are as follows.

Large primer leak (LPL) – 22 (13) *
Small primer leak (SPL) – 45 (26) *
Splits
  Neck and shoulder (J and S) – 49 (30) *
  Body (J) – 4 (2) *
  Body (K) – 1
Primer setback – no defect if not loose.
Failure to extract (FX) – 0
Weapon stoppage – 0

* Numbers in parentheses refer to reduced-sample testing when performed only in M14 and M60 weapons, such as that performed on TMP [illegible], Lot [illegible].

The above summary should be used only for interpretation of the proof test results presented in this section. Full details are available in the referenced specifications and regulations.

Three thousand rounds of steel-cased ball ammunition from Cartridge Lot FAX-S[illegible] were fired in an M134 Minigun for informational purposes. One-half the cartridges were fired using short bursts, the other half were fired "rapid fire". No functioning problems or case casualties were noted.

TABLE IV

PROOF TEST RESULTS

TMP 301

	Lot 4			Lot 4A			Lot 6D		
Vacuum									
Small leaks	0			—			—		
Large leaks	0			—			—		
Velocity (fps)									
+ 70° F	2774			2771			2771		
+125° F	—			2750			[illegible]		
− 65° F	—			2699			[illegible]		
Chamber Pressure (psi)									
+ 70° F	42,100			43,160			44,200		
+125° F	43,100			44,160			44,500		
− 65° F	39,200			42,600			41,900		
Bullet Pull (pounds)	215						[illegible]		
Function and Casualty	+70	+125	−65	+70	+125	−65	+70	+125	−65
M60	1SPL			2SJ		2J 1SPL	2SPL	0	5SPL
M52	—	—	—	—	—	—	2SPL	1SPL	2SPL
M14	6SPL 2J 1K 1SJ	4PS 4SPL	1S 1J 7SJ	2J 19SPL 1SJ	1J 2SPL	9J 4SPL 2SJ	0	0	0
G3	—	—	—	—	—	—	—	0	3SPL
LAR	—	—	—	—	—	—	—	1SPL	0
LIAI	—	—	—	—	—	—	—	1SPL	0
	Double sample in F and C testing								

— Test not performed

TABLE V
7.62MM STEEL CASE (HEAT TREATED)
FRANKFORD ARSENAL PROOF TEST RESULTS

CARTRIDGES LOTS FAX-8		3103	TRACER M62 3110	FAR-135	BALL M80 3103	3104	3167	[illegible]	3118	3114	3112	FAR-173
Accuracy M.R. 600 Yds		833	44	26	35	471	301	491	462	446	440	304
Velocity (fps)	+70°F	2738	2761	2764	2764	2733	2730	2764	2767	2756	2754	2737
	+160	2725	2734	2730	2741	2733	2705	2740	2731	2745	2741	2744
	+125	2755	2750	2727	2719	2727	2744	2781	2734	2715	2758	2719
	-65	2662	2657	2661	2610	2661	2691	2666	2657	2652	2654	2660
Chamber Pressure (psi)	+70°F	41700	43700	43400	38700	38100	40600	41000	38300	39700	31900	31900
	+160	41900	43900	43800	37200	38400	37700	42100	35400	41100	31900	37500
	+125	43000	42200	43300	37300	38100	41800	41000	38300	40800	38400	36000
	-65	29100	41300	43000	34400	35800	35900	37600	34300	38300	33100	32800
Port Pressure (psi)		11400	10900	10900	13800	13100	13100	12900	13300	13000	13000	11300
Action Time (ms)		1.515	1.36	1.37	1.38	1.36	1.33	1.37	1.31	1.19	1.41	1.385
Trace (%)		93	93	100								
Vacuum, Leakers of 50		12	6	0	3	1	2	13	1	14	11	1
			Retest 1 of 100							Retest ? of 100		
Bullet Pull (Lbs, Avg.)		182	220	[illegible]	169	194	204	191	193		187	204
Function and Casualty		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Blank space indicates	M60		a			d						a
satisfactory function	M52											b
and no casualties.	M14											
	03											
LOTS FAR-135 AND FAR-173	LAR											
NOT RECOMMENDED FOR M73.	L1A1											
	M73		a Insufficient Primer Hit	a Fail to Extract; b Fail to Eject	a Fail to Eject	[illegible]	[illegible]	a [illegible]		a [illegible]		a Broken Extractor; b Broken Extractor; c Fail to Eject; d Fail to Eject

CONCLUSIONS

As a result of the 7.62MM steel-case product improvement program, a process has been established and one million steel cases have been manufactured and submitted for ET/ST.

Ultimate determination of the success or failure of the program depends upon ET/ST results and TECOM recommendation regarding standardization.

The equipment used for steel case production is, in some instances such as heat treating and varnish application, not satisfactory for mass production. In the event that a change-over becomes necessary from brass to steel-case production, these areas will require further development.

New methods and concepts for manufacture of a better-quality, lower-cost steel case are being investigated. Presently underway are studies of extrusion from bar stock, cold working in lieu of heat treating, and automated non-destructive testing to eliminate human error during final inspection. In addition, studies in steel-case development for other calibers are continuing.

RECOMMENDATIONS

Recommendations regarding the future of 7.62MM heat-treated steel case development depend upon ET/ST results. In the event that type classification as STD A is recommended, the process will be shelved following standardization, for possible future use in the event that copper becomes unavailable.

If standardization is not recommended, TECOM test results will be reviewed to determine problem areas and their possible causes. If it is determined that satisfactory performance can be obtained with little additional effort, it is recommended that appropriate measures be taken to correct the deficiencies. If it is determined that correction of deficiencies would require much additional development, it is recommended that the process be shelved along with documentation indicating the level of performance obtained and suggestions for necessary modifications to the process in the event that change-over to steel case production becomes necessary and/or economically feasible.

APPENDIX A

TMP 301

Summary of Case Lots

Lot	Qty	Process Used
1	4,000	Cupped from LC strip
		1.27 wash, rust preventive rinse, and dry omitted.
		1.30 temper to take place within two hours after 1.28 harden; - quantity remaining too small to proof test.
2		Cupped from LC strip -- discontinued due to problems at blank and cup.
3		Cupped from LC strip - discontinued due to problems at blank and cup.
4	25,000	Cupped from 1st coil of Republic steel
		Hardness after 1.3 anneal 59-62 R_B
		Hardness after 1.7 anneal 55-58 R_B
		Wall thickness at 1.5 first draw measured at 0.437"
		Deburring punch FB 56637 used at 1.21 vent and deburr.
		Phosphate coat only at 1.23 phosphate coat and lubricate.
		Mineral oil used at 1.24 taper and plug, and 1.35 retaper and replug.
		1.17 phosphate coat and lubricate, and 1.32 mouth and neck anneal eliminated.
		Alternate tooling used at 1.15 trim, 1.24 taper and plug, and 1.35 retaper and replug.
		1.27 wash, rust preventive rinse, and dry eliminated.
		1.39 varnish performed on Rezci machine. Immersion time 2 min, centrifuge time 2 1/2 min, varnish viscosity 28 sec - Zahn No. 2 cup. Cured 400° F, for 30 min.
4a	2,500	Taken from 25,000-piece, lot 4
		1.30 temper at 875° F
		Case casualties in function and casualty testing.
5	20,000	Cupped from 2d coil of Republic steel.
		Suspended during processing of lot 6a - d.
6	19,000	Divided into lots 6a to 6d.
		Cupped from 3d coil of Republic steel
6a	2,000	Taken from 19,000-piece, lot 6.
		Intended for processing same as lot 4a, until poor results were encountered in proof testing. Not processed.
6b	2,000	Entire head turned piece annealed at 1340° F, in lieu of body anneal.
		Suspended in favor of lot 6d process.

* Numbers refer to operations in TMP 301, Appendix D

APPENDIX A (cont) "TMP 301" Summary of Case Lots

Lot	Qty	Process Used
6c	2,000	Processed as lot 4, but utilizing .4455" body tapering die instead of .4480. Suspended in favor of lot 6d process
6d	2,000	Processed as lot 4, but without 1.22 body anneal and 1.22 phosphate coat. Gave satisfactory results in proof testing.
7	25,000	Cupped from 4th coil of Republic steel. Suspended after lot 6d indicated success.
8	25,000	Cupped from 5th coil of Republic steel. Suspended after lot 6d indicated success.
9	25,000	Cupped from 6th coil of Republic steel. Hardened and tempered prior to third draw. Suspended after lot 6d indicated success.
10		Composed of cups from lots 4 – 5, having excessive wall variation. Suspended after lot 6d indicated success.

APPENDIX B

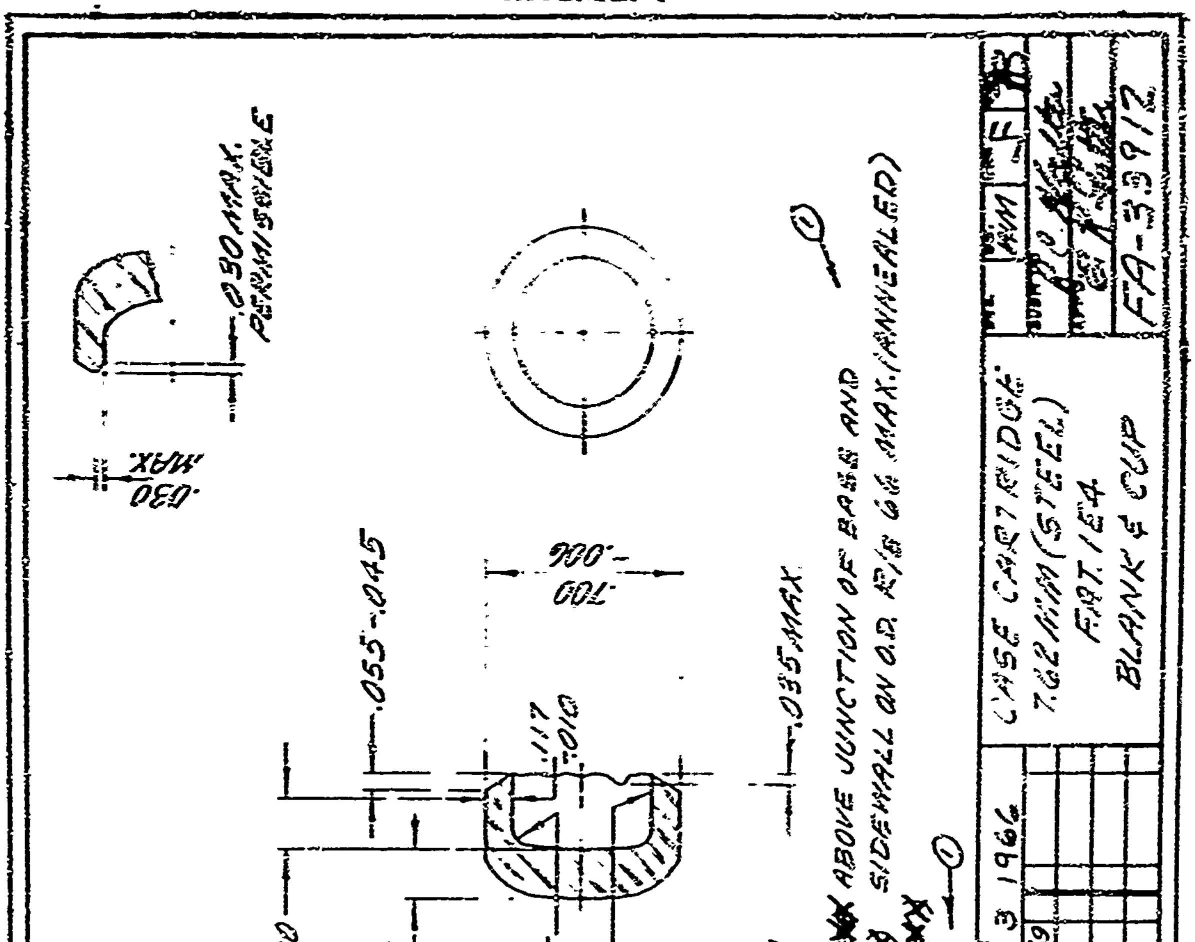
TMP 305

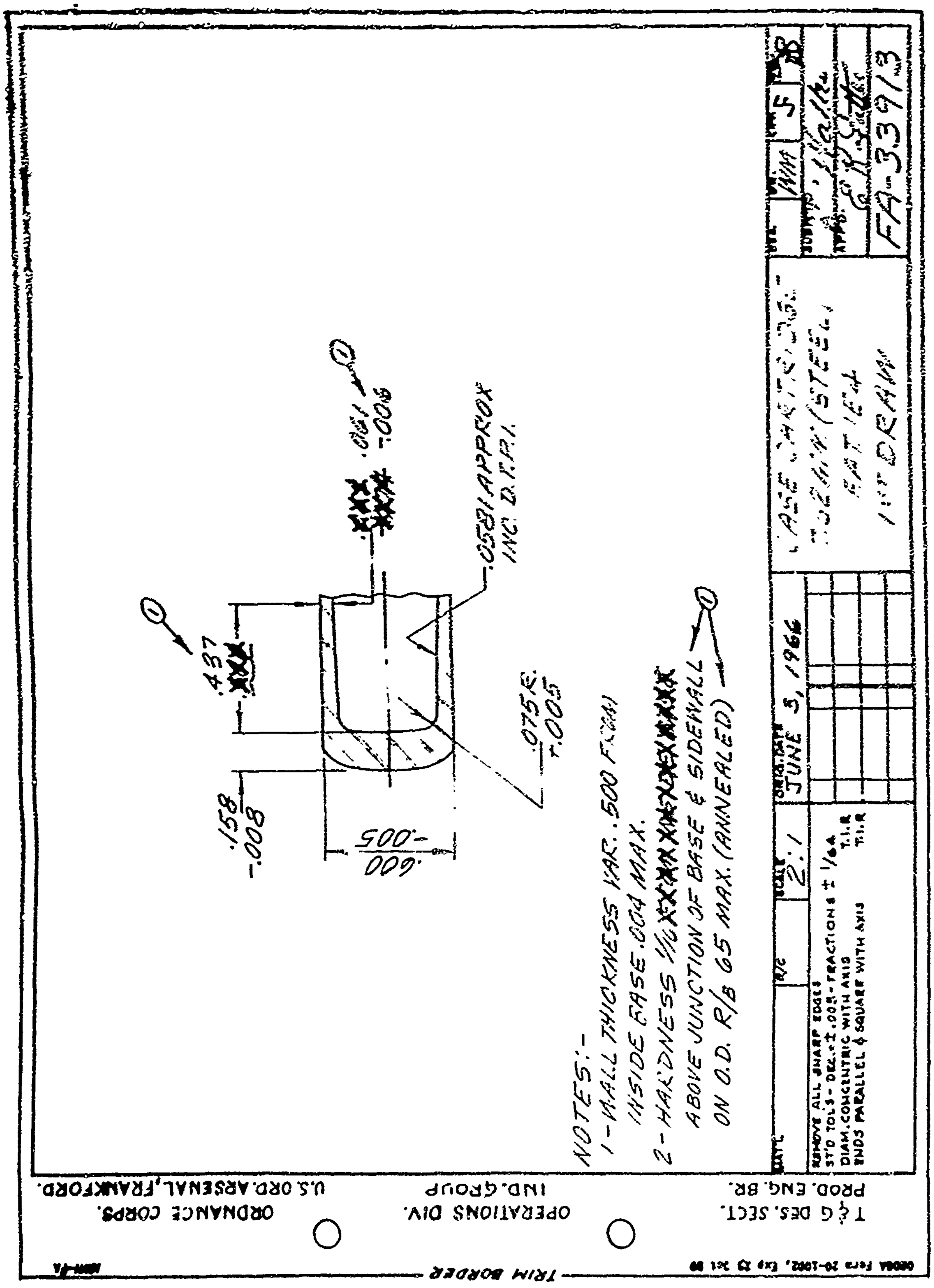
Summary of Cartridge Lots

Lot	Qty	Type	Date Accepted
FAX-S3104	77,720	Tracer	31 Oct 67
FAX-S3105	98,880	Ball	7 Nov 67
FAX-S3106	87,040	Ball	16 Nov 67
FAX-S3107	93,400	Ball	17 Nov 67
FAX-S3111	64,160	Ball	5 Dec 67
FAX-S3113	53,600	Ball	22 Jan 68
FAX-S3114	97,280	Ball	31 Jan 68
FAX-S3115	125,440	Ball	9 Feb 68
FAX-S3116	88,480	Tracer	8 Feb 68
FAX-S3127	101,200	Tracer	25 Apr 68
FAX-S3128	113,160	Ball	16 May 68

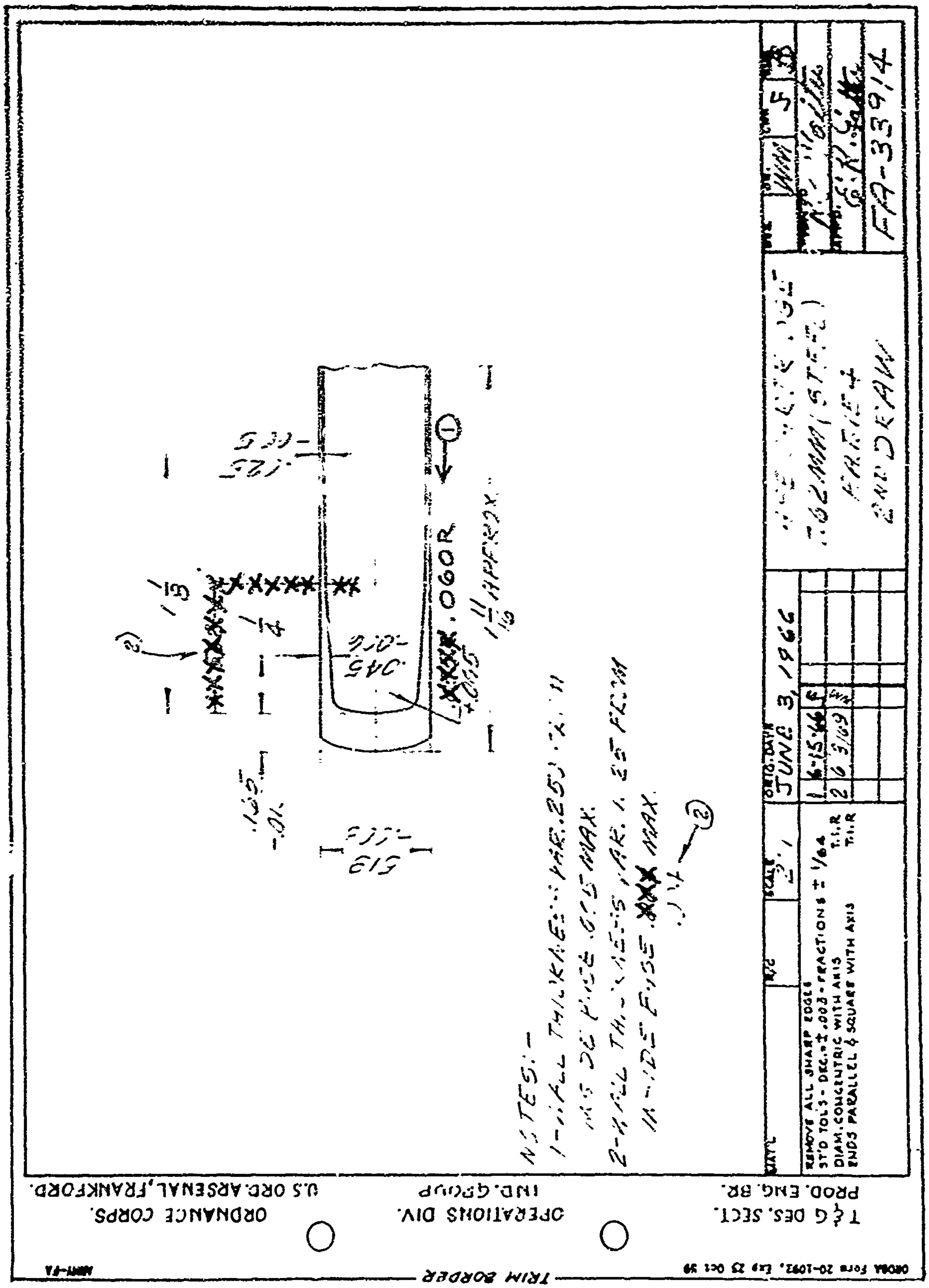
Functional Cartridge Lots

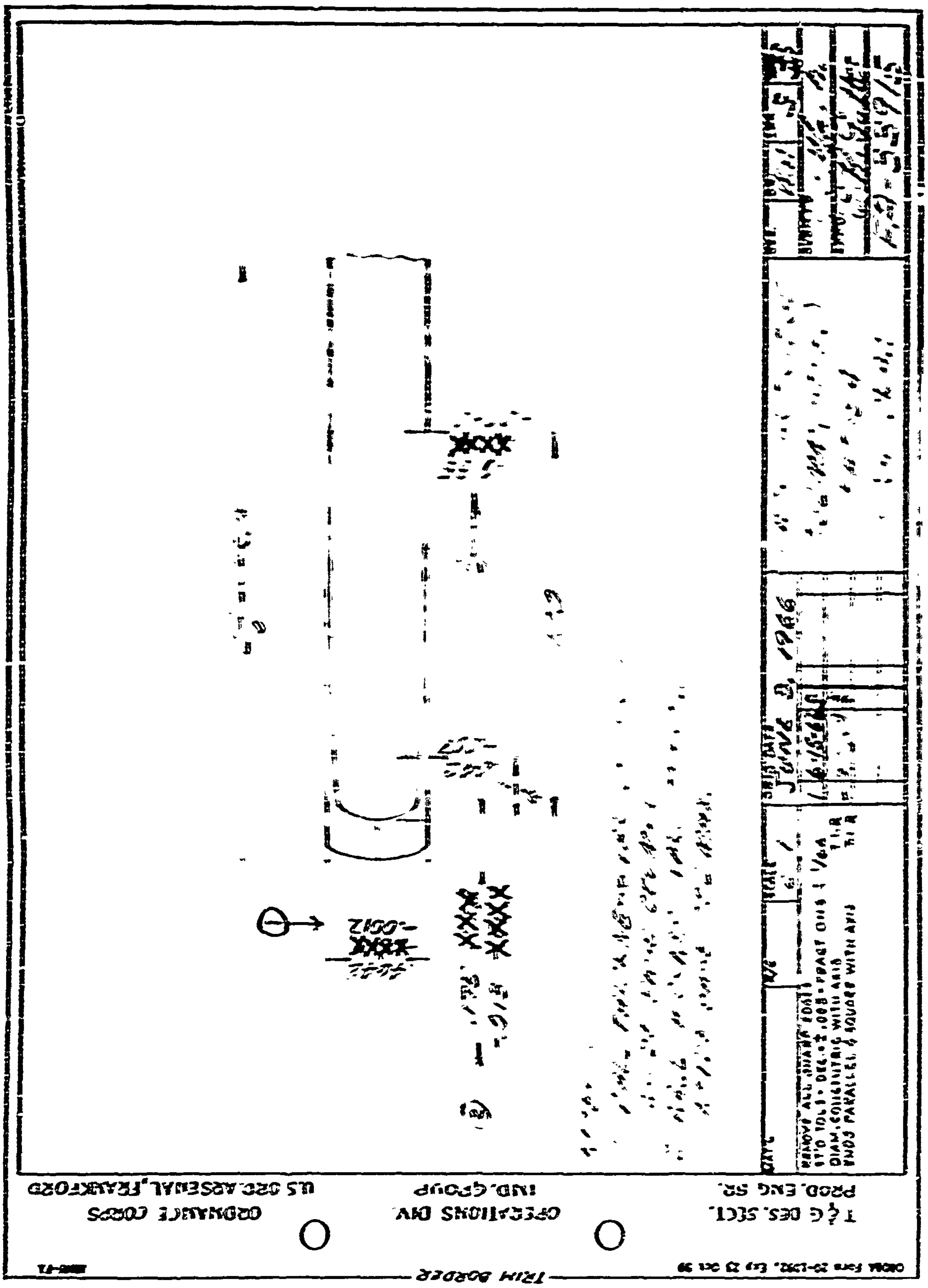
	Qty	Composed of	
FAXL -S- 3108	81,600	3105 Ball	65,280
		3104 Tracer	16,320
FAXL -S- 3109	108,800	3106 Ball	87,040
		3104 Tracer	21,760
FAXL -S- 3110	99,200	3107 Ball	79,360
		3104 Tracer	19,840
FAXL -S- 3112	40,800	3111 Ball	32,640
		3104 Tracer	8,160
FAXL -S- 3117	18,400	3113 Ball	14,720
		3104 Tracer	3,680
FAXL -S- 3118	121,600	3114 Ball	97,280
		3116 Tracer	24,320


NOTES:-
1- WALL THICKNESS VAR. .180 FROM
INSIDE BASE .004 MAX.
2- HARDNESS 1/16 ABOVE JUNCTION OF BASE AND
SIDEWALL ON O.D. R/B 66 MAX. (ANNEALED)
3- WEIGHT:-
202-14 GRAINS
.180
.156 -.006
.065R -.005
.047 D.T.P.I. APPROX.
.055 -.045
.117 -.010
.700 -.006
.035 MAX
.030 MAX.
.030 MAX.
CASE CARTRIDGE
7.62MM (STEEL)
FIRT. 1E4
BLANK & CUP
FA-33912
SCALE 2:1
JUNE 3 1966
1 6/3/69
REMOVE ALL SHARP EDGES
STD TOLS - DEC. ± .005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R.
ENDS PARALLEL & SQUARE WITH AXIS T.I.R.
T & G DES. SECT.
PROD. ENG. BR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.
TRIM BORDER



NOTES:-
1-WALL THICKNESS VAR. .500 FROM INSIDE BASE .004 MAX.
2-HARDNESS ABOVE JUNCTION OF BASE & SIDEWALL ON O.D. R/B 65 MAX. (ANNEALED)
.437
.158
-.008
.600
-.005
.075R.
±.005
.0581 APPROX
INC. D.T.R.I.
REMOVE ALL SHARP EDGES
STD TOLS - DEC. ±.005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R.
ENDS PARALLEL & SQUARE WITH AXIS T.I.R.
SCALE 2:1
ORIG. DATE JUNE 5, 1966
1ST DRAW
FA-33913
T & G DES. SECT.
PROD. ENG. BR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.
TRIM BORDER


FA-33914
JUNE 3, 1966
7.62MM
2ND DRAW
NOTES:
REMOVE ALL SHARP EDGES
STD TOLS - DEC. ± .005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS
ENDS PARALLEL & SQUARE WITH AXIS
T & G DES. SECT.
PROD. ENG. BR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.
TRIM BORDER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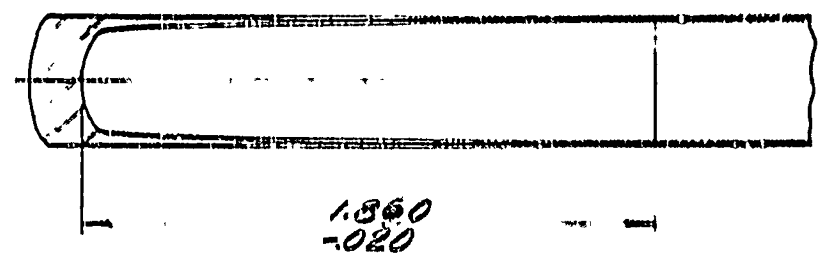
T & G DES. SECT.
PROD. ENG. SR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS
U.S. ORD. ARSENAL, FRANKFORD
-.0012
JUNE 2, 1966



MAT'L	R/C	SCALE 2:1	ORIG. DATE JUNE 3, 1966

REMOVE ALL SHARP EDGES
ST'D TOL'S - DEC. ± .005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R
ENDS PARALLEL & SQUARE WITH AXIS T.I.R

CASE CARTRIDGE
7.62MM (STEEL)
A.A.T. IE4
1st TRIM

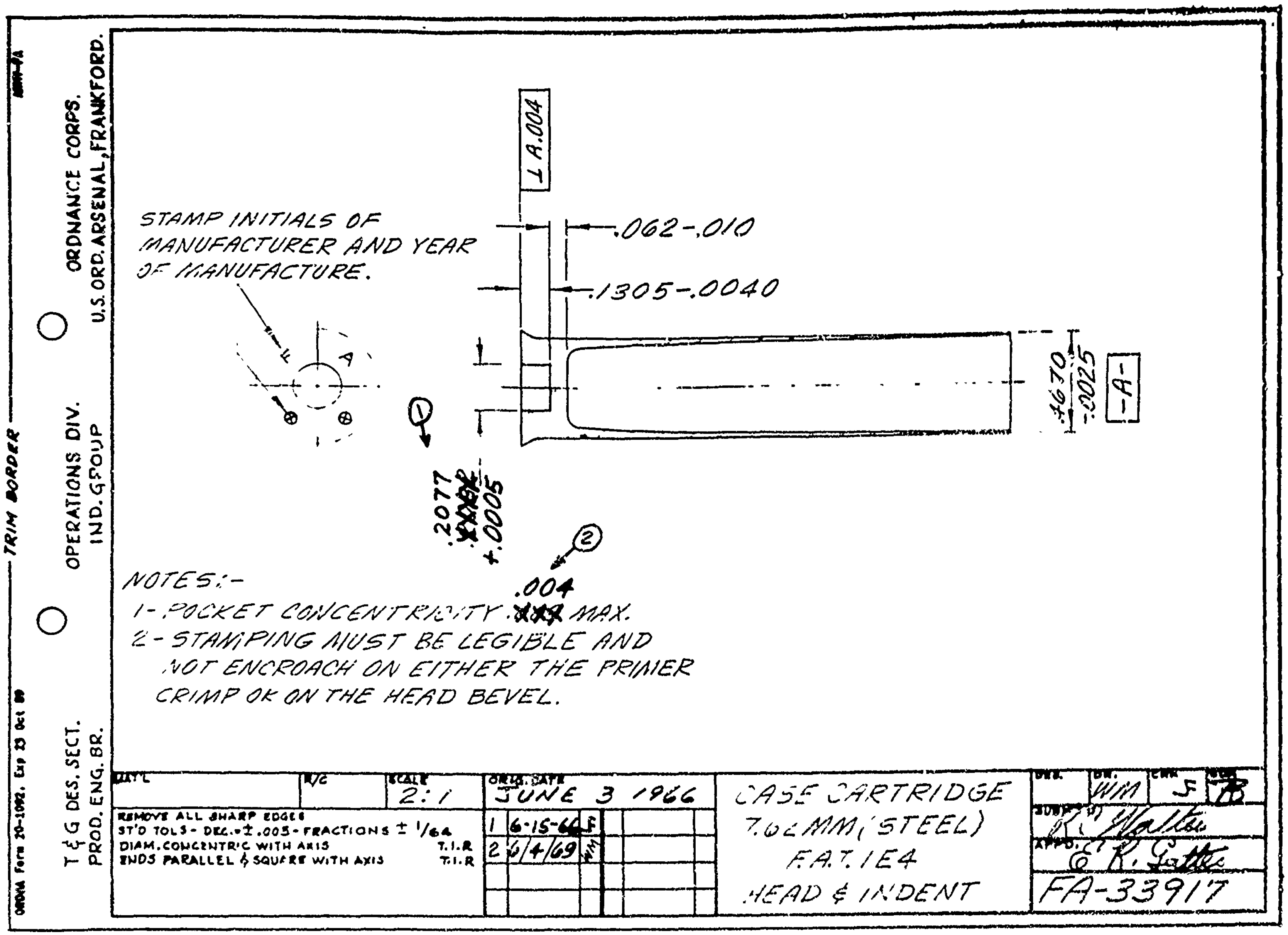
DR. WM
APPD. E.R. Gutt
FA-33916

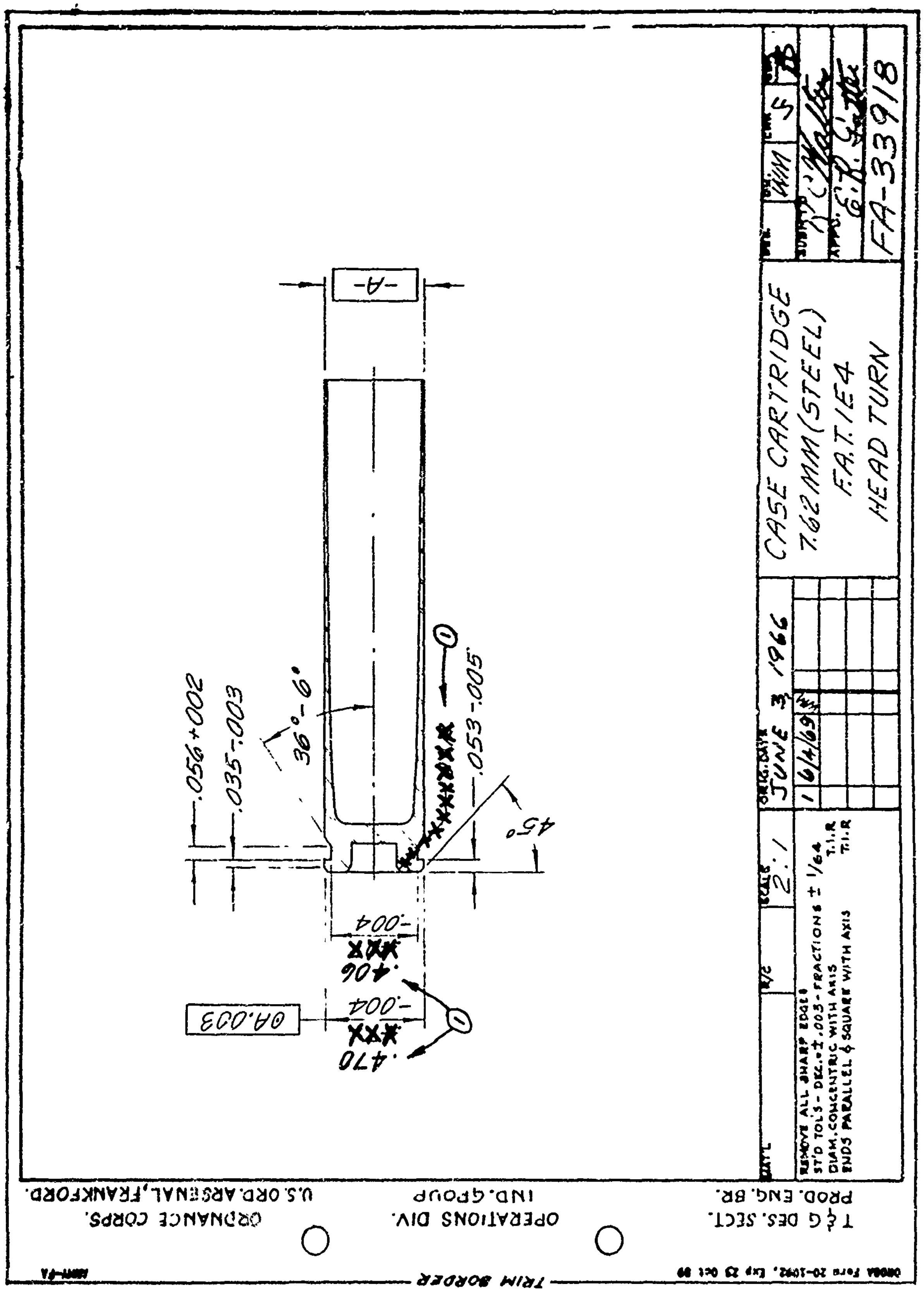
T & G DES. SECT.
PROD. ENG. BR.

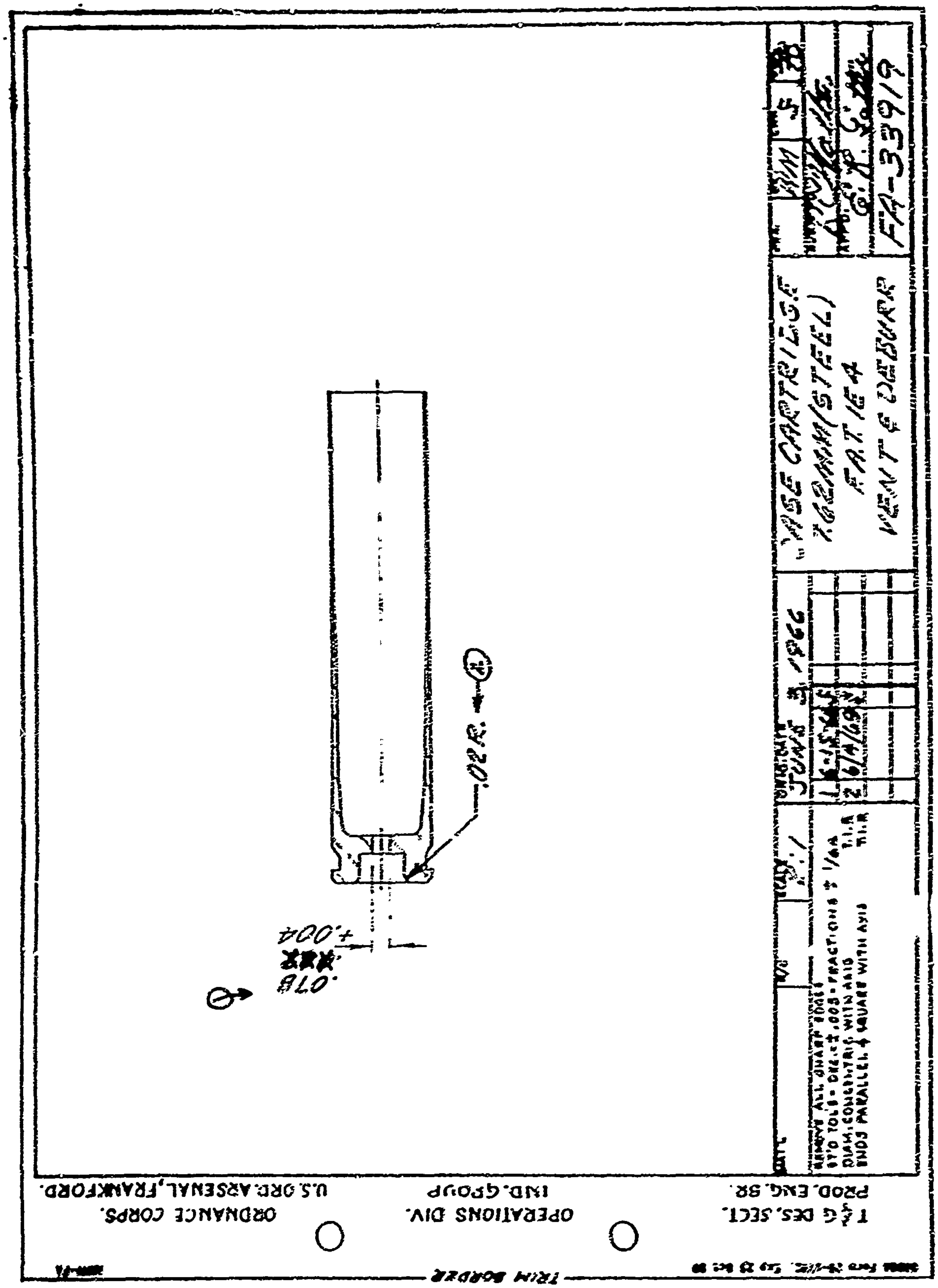
OPERATIONS DIV.
IND. GROUP

ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.

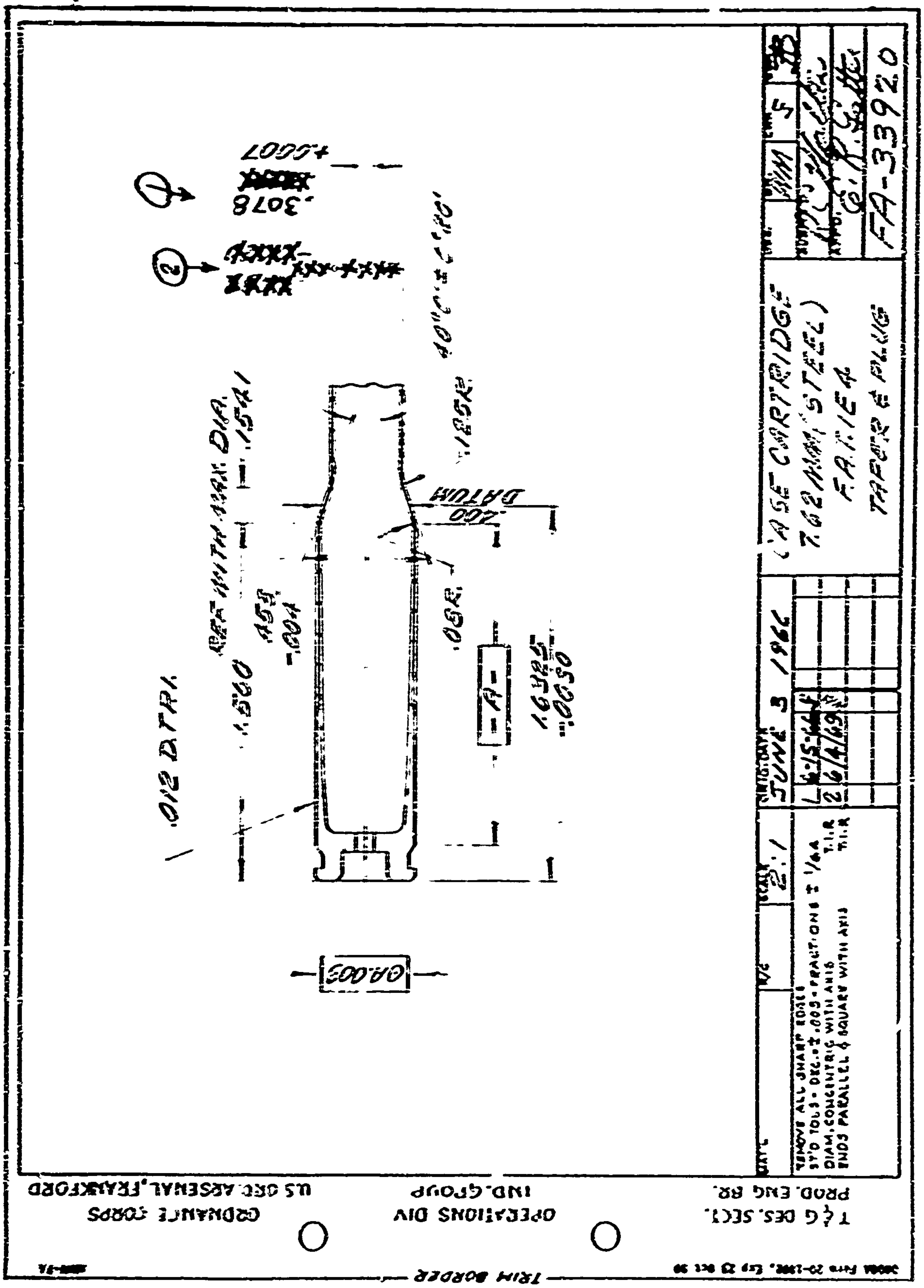
TRIM BORDER


STAMP INITIALS OF MANUFACTURER AND YEAR OF MANUFACTURE.
⊥ A.004
.062-.010
.1305-.0040
.4670 -.0025
-A-
A
.2077 ~~XXXX~~ +.0005
.004
NOTES:-
1- POCKET CONCENTRICITY .004 ~~XXX~~ MAX.
2- STAMPING MUST BE LEGIBLE AND NOT ENCROACH ON EITHER THE PRIMER CRIMP OR ON THE HEAD BEVEL.
ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.
OPERATIONS DIV.
IND. GROUP
T & G DES. SECT.
PROD. ENG. BR.
TRIM BORDER
ORDNA Form 20-1092, Exp 23 Oct 59
MAT'L
SCALE
2:1
ORIG. DATE
JUNE 3 1966
1 6-15-66
2 6/4/69
REMOVE ALL SHARP EDGES
ST'D TOLS - DEC. ± .005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R
ENDS PARALLEL & SQUARE WITH AXIS T.I.R
CASE CARTRIDGE
7.62 MM (STEEL)
F.A.T. 1E4
HEAD & INDENT
WM
FA-33917

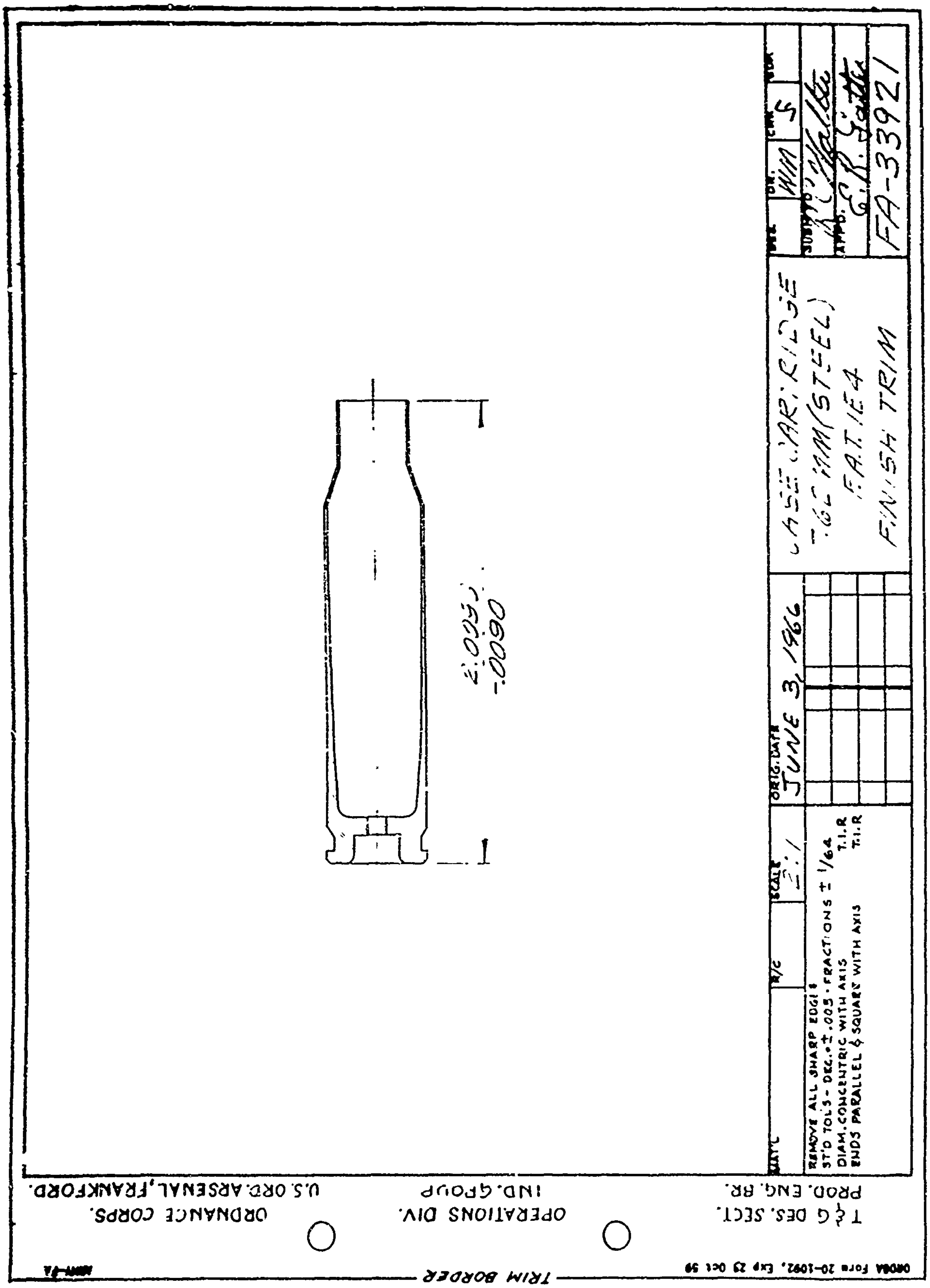

CASE CARTRIDGE
7.62 MM (STEEL)
F.A.T.1E4
HEAD TURN
FA-33918
SCALE 2:1
ORIG. DATE JUNE 3 1966
1 6/4/69
-A-
.056+.002
.035-.003
36°-6'
.053-.005
45°
.406
-.004
.470
-.004
0A.003
REMOVE ALL SHARP EDGES
STD TOL'S - DEC. ±.003 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R.
ENDS PARALLEL & SQUARE WITH AXIS T.I.R.
T & G DES. SECT.
PROD. ENG. BR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.
TRIM BORDER



CASE CARTRIDGE
7.62MM (STEEL)
F.A.T. 1E4
VENT & DEBURR
FA-33919
JUNE 3 1966
REMOVE ALL SHARP EDGES
STD TOLS - DEC. ±.005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R.
ENDS PARALLEL & SQUARE WITH AXIS T.I.R.
.02 R.
.078
+.004
T & G DES. SECT.
PROD. ENG. BR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS.
U.S. ORD. ARSENAL, FRANKFORD.
TRIM BORDER



FA-33920
7.62MM (STEEL)
TAPER & PLUG
DATUM
OPERATIONS DIV
IND. GROUP
PROD. ENG BR.
TRIM BORDER


CASE CARTRIDGE
7.62MM (STEEL)
F.A.T.1E4
FINISH TRIM
FA-33921
ORIG. DATE JUNE 3, 1966
SCALE 2:1
REMOVE ALL SHARP EDGES
STD TOLS - DEC. ± .005 - FRACTIONS ± 1/64
DIAM. CONCENTRIC WITH AXIS T.I.R
ENDS PARALLEL & SQUARE WITH AXIS T.I.R
T & G DES. SECT.
PROD. ENG. BR.
OPERATIONS DIV.
IND. GROUP
ORDNANCE CORPS
U.S. ORD. ARSENAL, FRANKFORD.
TRIM BORDER

APPENDIX D

FRANKFORD ARSENAL
SMALL CALIBER ENGINEERING DIRECTORATE
ENGINEERING DIVISION TMP 301-7.62mm

Project Engineer: Walter Weis, U2200, Ext. 4233

Project Coordinators: P. Bertino, U4100, Ext. 22251
S. White, U4100, Ext. 22251

Subject: Case, Cartridge, Steel, 7.62mm FATIE4, Establish Manufacturing Process

Requirements and Instructions:

Industrial Services Directorate, X1000

1. Purchase sufficient steel strip (phosphate coated and lubricated preferred) in accordance with Specification MIL-S-645 having a carbon content of 0.22 to 0.28 percent and a thickness of 0.150" ± 0.006" to produce 150,000 cups. Process the cups in 25,000 lot samples when requested by Project Coordinators through the following sequence of operations, using the tools, inspection limits, hardness controls and solutions listed. Identify each sample lot in sequence beginning with TMP No. 301-7.62mm, Lot 1. Strip width 5.125 ± 0.010.

1.1 Blank & Cup

Press: crank, vertical, double action - Bliss No. 6
Tools: Blanking punch SKFSA 11205 Rev. A
Cupping punch SKFSA 11206
Blank & cup die SKFSA 11207 Rev. B
Stripper SKFSA 11208
Stripper spring PT-1006
Gages & limits: SKFSA 9863 - outside diam. - 0.694-0.700
SKFSA 9864 - base thick. - 0.150-0.156
SKFSA 9865 - wall thick. 0.180 from inside base -0.107-0.117
wall thick. var. 0.180 from inside base-0.004 max.
wall height var.-0.035 max.
weight-194 grs. (approx.)
Solution: 1 1/2 parts water to 1 part Lubro #44 or
4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base-R_B 80 to 86

1.2 Wash

Barrel: metal, rotary, inclinable, Baird.
Solution: Hot water, 4 cups tri-sodium phosphate; wash for 1/2 hour; Rust preventive: potassium dichromate added to final rinse.

1.3 Anneal

Furnace: Lindberg, atmosphere controlled
Hardness: 1/16" from inside base - R_B 48-55

1.4. Phosphate coat & lubricate

Machine: Ransomatic unit

1.5 First Draw

Press: crank, vertical, duplex - Bliss No. 62

Tools:	Punch	PT 1291
	Guide ring	FB 52210
	Top die	PTC 1982
	Bottom die	PTC 1983
	Stripper	PT 1294A
	Stripper holder	PT 1005
	Stripper spring	PT 1006

Gages & Limits: SKFSA 9866 - outside diam. 0.595-0.600
FB 36261 - base thick. 0.150-0.158
SKFSA 9867 - wall thick.
0.500 from inside base 0.058-0.062
wall thick. var.
0.500 from inside base 0.004 max.

Solution: 4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base - R_B 80 to 86

1.6 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water

1.7 Anneal:

Furnace: Lindberg, atmosphere controlled
Hardness: 1/16" from inside base R_B 48 to 55

1.8 Phosphate Coat & Lubricate

Machine: Ransomatic Unit

1.9 Second Draw

Press: crank, vertical, single action - Bliss No. 304

Tools:	Punch	PT 1901
	Guide ring	FB 52211
	Top die	PTC 1902
	Lub. ring	SKFSA 10768
	Bottom die	PTC 121A
	Stripper	PT 1003D
	Stripper holder	PT 1005B
	Stripper spring	PT 1006

Gages & Limits:
FB 36052 - outside diam. 0.516-0.519
SKFSA 9873 - base thick. 0.155-0.165
SKFSA 9874 - wall thick.
1/4" from inside base 0.039-0.045
wall thick. var.
1/4" from inside base 0.005 max.
wall thick.
1 1/8" from inside base 0.020-0.025
wall thick. var.
1 1/8 from inside base 0.003 max.

Solution: 4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base R_B 81 to 86

1.10 Wash, Rust Preventive Rinse & Dry

Washer:	Niagara
Solution:	9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive:	3 oz. of potassium dichromate added to rinse water

1.11 Anneal

Furnace: Lindberg, atmosphere controlled
Hardness: 1/16" from inside base R_F 48 to 55

1.12 Phosphate Coat & Lubricate

Machine: Ransomatic unit

1.13 Third Draw

Press: crank, vertical, single action - Bliss No. 304

Tools:

Punch	FB 52212
Guide ring	SKFSA 10770
Top die	PTC 131A
Bottom die	PTC 132B
Stripper	PT 1004E
Stripper holder	PT 1005B
Stripper spring	PT 1006

Gages & Limits:

FB 17480 - outside diam. 0.4630-0.4642
FB 22303 - base thick.
FB 23471 - wall thick.
1/4" from inside base 0.035-0.042
wall thick. var.
1/4" from inside base 0.006 max.
FB 23471 - wall thick.
1.70 from inside base 0.0095-0.0125
wall thick. var.
1.70 from inside base 0.002 max.

Solution: 4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base R_B 73 to 79

1.14 Wash, Rust Preventive Rinse & Dry

Washer:	Niagara
Solution:	9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive:	3 oz. potassium dichromate added to rinse water

1.15 Trim:

Machine: horizontal, single spindle

Tools:

Cutter	PT 126A
Spindle	PT 1904
Sleeve	PT 1907
Stripper ring	PT 138
Nut	PT 1906
Burring cutter	PT 1905
Spring	PT 1971

Gages & Limits:

SKFSA 9871 - inside length 1.840-1.860

1.16 Sort

Inspection Belt

1.17 Phosphate Coat & Lubricate

Machine - Ransomatic unit

1.18 Head

Press:	horizontal toggle & crank	
Tools:	Die	PT 146E
	Eject stem	PT 142C
	Punch (1 pc.)	PT 1038J (Modify pilot to size shown on SKFSA 11277)
	Punch (2 pc.)	SKFSA 11277
	Punch holder	SKFSA 11276

Gages & Limits:

FB 22321 - outside diam. 0.4645-0.4670
SKFSA 9869 - pocket diam. 0.2077-0.2082
FB 22323 - pocket depth 0.1265-0.1305
FB 22303 - web thickness 0.052-0.062
FB 23482 - pocket concentricity 0.003 max.
FB 23380 - head crookedness 0.004 max.

1.19 Wash, Rust Preventive Rinse & Dry

Washer:	Niagara
Solution:	9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive:	3 oz. potassium dichromate added to rinse water

1.20 Head Turn

Machine:	horizontal single spindle	
Tools:	Collet	PT 1008B
	Spring	PT 1009
	Form tool	FB 52213

Gages & limits:

FC 2884 - head diam.	0.467-0.471
FC 2927 - head thick.	0.048-0.053
FC 2884 - ext. groove diam.	0.403-0.407

1.21 Vent & Deburr

Machine: W.F.F. Primer Insert

Tools: Burr

	Punch	PT 1025
	Stem	FB 186383
Vent		
	Punch holder	PT 170B
	Punch	FB 36474
	Die	FB 36475
	Stem	FB 36476
1st No. Vent Detect		
	Holder	PT 176A
	Clamp	PT 179A
	Stem	PT 177B
	Detect Pin	PT 178

2nd No. Vent Detect - same as 1st No. Vent Detect

Gages & Limits:

SKFSA 9868 - diam. of vent hole 0.078-0.082

Note: Operation and tools mentioned above are to be used when two piece heading punch is used at heading operation. If one piece heading punch is utilized, the Derbyshire venting machine shall be used. Tools for this operation to be established.

1.22 Body Anneal

Machine: gas (induction preferred - requires development for application in Phase II)

Hardness: Rockwell 15T (sectioned case)

distance from mouth	hardness
1/8"	79-83
1/2"	79-83
3/4"	79-83
7/8"	89 min

1.23 Phosphate Coat & Lubricate

Machine: Ransomatic Unit

1.24 Taper & Plug

Press: vertical, double action, crank - Bliss No. 152

Tools:

Mouth ironing punch	T 7342
Mouth ironing die	PT 1000
Mouth ironing spring	PT 1012
Shoulder die	PTC 1921A
Body die	PTC 1989
Eject stem	PT 1918
Plug punch	PT 159A

Gages & Limits:

FB 23520 - profile of body
SKFSA 9870 - mouth diam. 0.3078-0.3085
FB 23522 - length, head to shoulder 1.6295-1.6325
FB 23460 - neck diam. 0.3413-0.3433

Lubricant: lard oil (if necessary)

1.25 Wash, Rust Preventive Wash & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water

1.26 Finish Trim

Machine: vertical, single spindle

Tools:

Cutter	PTC 1010B
Cutter holder	PT 1011B
Support Cover	PT 1011B
Retainer Seat	PT 1923
Case Support	T 7242
Cutter Clamp	PT 1015A

Gages & Limits:

FB 23526 - total length 2.0003-2.0093

1.27 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water

1.28 Harden

Machine:	Westinghouse induction unit
Hardness:	1/16 above extractor groove - R_C 42-50
Temperature:	1650°F $\pm$ 10°F
Quench Solution:	Caustic Soda 6% $\pm$ 0.5%
Quench Solution Temp:	60°F $\pm$ 5°F

1.29 Same as Operation #1.27

1.30 Temper

Furnace:	Lindberg electric recirculating air
Temperature:	800°F $\pm$ 10°F for 75 minutes
Hardness:	1/16 above extractor groove - R_C 22 to 28

1.31 Pickle & Rinse

Machine: Blakeslee pickling unit

1.32 Wash, Rush Preventive Rinse & Dry

Washer:	Niagara
Solution:	9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive:	3 oz. of potassium dichromate added to rinse water

1.33 Mouth & Neck Anneal

Machine: horizontal straight-line twin screw conveyor, gas
Hardness: Rockwell 15T

Distance from Mouth	Hardness
1/8"	82-86
1/4"	88 min

1.34 Wash, Rust Preventive & Dry (if necessary)

1.35 Retaper & Replug

Press: vertical, double action, crank - Bliss No. 162
Tools: Plugging punch PT 159A
Shoulder die PTC 1990
Body die PTC 1989
Gages & Limits:
SKFSA 9870 - mouth diam. 0.3078-0.3085
FB 23520 - profile of body
FB 25522 - length, head to shoulder 1.6295-1.6325
FB 23460 - neck diam. 0.3413-0.3433
Lubricant: lard oil

1.36 Wash, Rust Preventive Rinse & Dry - Same as #1.32

1.37 Visual Inspect

1.38 Iron Phosphate - to be established and verified

1.39 Varnish - to be established and verified

1.40 Visual inspect

1.41 Prime, Load, Insert Bullet, Gage & Weigh & Inspect -

Same machines as shown in the Operations Control Section pertaining to Cartridge, Ball, NATO, 7.62mm, M80

2. Furnish gages required to accomplish this project

3. Record the following information:

3.1 number of pieces processed through each operation

3.2 amount of scrap obtained at each operation

3.3 number of pieces processed by each tool

3.4 reason each tool is discarded

3.5 amount and cause of downtime

3.6 annealing and heat treating data (time in each zone, time in cooling chamber, temperature in each zone, temperature and strength of quench solution

3.7 machine speeds

4. Record and submit a record of DPC bullet pull, velocity, pressure and waterproof tests taken at loading operation.

5. Perform a hardness test on five pieces taken hourly from each of the interdraw anneals, the body and mouth and neck anneals, the temper anneal and quench harden operations. Submit results to project coordinators.

6. Measure five pieces from each cup and draw punch every hour. Record and submit results to project coordinators.

7. Measure five pieces every 30 minutes from the trim operation through all subsequent operations with the exception of the taper and plug and retaper and replug operations, which shall be measured every 15 minutes. Record and submit measurements to project coordinators.

8. Submit a copy of the cartridge case 100% visual inspection before and after varnishing operation, the gage and weigh operation and the 100% cartridge visual inspections to the project coordinators. (Note: it may be necessary to reduce the speed of the inspection operations to obtain proper inspection.)

9. Perform a measurement survey (periodic check) on a sample of ten cartridge cases each taken at the beginning and end of each day.

10. Perform a weight check on samples of ten cartridge cases each, taken from the 2nd 100% visual inspection. The samples shall be taken at the beginning and end of each day.

11. Perform a hardness check on samples of ten cartridge cases each, taken from the 1st 100% visual inspection. The samples shall be taken at the beginning and end of each day. Take readings at positions shown on drawings D10521997. Readings on the head and on the sidewall from the head up to and including the 1.5 inch position shall be read on the Rockwell 15N scale. Position 1.775 shall be read on the Rockwell 15T scale.

12. Perform a hardness test on the strip at the beginning and end of each coil.

13. Supply a sufficient quantity of Bullets, Ball, NATO, 7.62mm, M80 to accomplish tests.

14. Supply a sufficient quantity of primers No. 34 to accomplish tests.

15. Supply a sufficient quantity of Western Ball propellant to accomplish tests.

16. Maintain identity of work through all operations.

17. Furnish a complete cost breakdown of expenditures to Project Engineer.

18. Forward quantities of cartridges specified by Project Coordinators to the Engineering Proof Testing Laboratories, E4200, when requested.

19. Pack cartridges when requested by Project Coordinators.

20. Section cartridge cases as requested by Project Coordinators.

21. Remove tools from machine as each operation is completed and store properly identified.

22. Manufacture additional tools as requested.

Pitman-Dunn Research Laboratories, L1000
Mechanical Metallurgy Branch, L7200

23. Furnish photomicrographs of the steel strip microstructure - 750 magnification.

24. Furnish photomicrographs of samples of three components each taken from the interdraw anneals and hardening and tempering operations. Photomicrographs shall be taken of the middle wall area using 750 magnifications.

25. Examine a sample of five cartridge cases each for cold shut determination. Take photomicrographs of them (100 magnification).

Test and Evaluation Division, Q6000
Basic Materials Evaluation Branch, Q6100

26. Perform a wet chemical analysis on a sample of steel cartridge case strip from each coil.

27. Perform hardness determinations as requested by Project Coordinators.

Environmental Branch, Q6200

28. Perform a salt spray test utilizing a 5% solution on a sample of five cartridge cases. Method of test shall be in conformance with Federal Test Method Standard No. 151.

29. Perform a salt spray test utilizing a 5% solution on a sample of five cartridges. Method of test shall be in conformance with Federal Test Method Standard No. 151.

Small Caliber Engineering Directorate, U1000
Ammunition Engineering Branch, U4100

30. Forward samples of steel cartridge case strip to Basic Materials Evaluation Branch, Q6100 for a wet chemical analysis.

31. Forward samples of the steel cartridge case strip to Mechanical Metallurgy Branch, L7200, for photomicrographs of grain structure.

32. Forward three components from each interdraw anneal and hardening operation to Mechanical Metallurgy Branch, L7200 for photomicrographs of grain structure.

33. Forward five finished cases to Mechanical Metallurgy Branch, L7200, for cold shut determinations and photomicrographs. Take from Head Operation.

34. Forward samples of finished cases to the Basic Materials Evaluation Branch, Q6100, for hardness determinations.

35. Forward samples of varnished cartridge cases and cartridges assembled with varnished cases to Environmental Branch, Q6200, for salt spray testing.

36. Properly identify all samples as to program number, operation and type of test to be performed.

APPENDIX E

FRANKFORD ARSENAL
AMMUNITION DEVELOPMENT & ENGINEERING LABORATORIES
ENGINEERING DIVISION TMP-305-7.62MM, STEEL

Project Engineer:	Walter Weis, J7200, Ext 4233
Tool & Component Design Engineer:	Rudolph Grosskurth, J7200, Ext 4194
IED Technical Administrator:	Joseph Charno, J9100, Ext 3241
Process Engineers:	Peter Bertino, J9100, Ext 22251
	S. White, J9100, Ext 22251
Support Engineering:	
Metallurgy:	E. Dougherty, J4500, Ext 24195
Chemistry:	W. Svekla, J4400, Ext 24285
Subject:	Manufacture of 1 Million Case, Cartridge, Steel, 7.62mm, FAT1E4 and Assembly into Cartridges, M80 & M62 for Engineering and Service Tests

Instructions and Requirements:

1. Sufficient steel (40 tons) to produce 1 million 7.62mm steel cartridge cases, drawing No. FB 30544, was ordered from Sharon Steel Co. in two heats. The first heat (approximately 45,000 lbs) heat No. 529328 will be delivered to Frankford Arsenal on or about 17 April 1967. This steel has a carbon content of .26%. The second heat will be poured to supply the remainder of the order by 15 May 1967. The steel will not be phosphate coated. ISD shall process this strip in the following manner using the sequence of operations, tools, inspection limits, hardness controls, and solutions listed below.

NOTE: It is imperative that the information requested throughout this TMP be gathered as required. This information is required to prepare specifications, Technical Data Packages, manufacturing procedures, and a final report at the completion of the program. Therefore, each area responsible for portions of this TMP shall acknowledge by submitting the information monthly starting May 1967, to the Project Engineer, Mr. Walter Weis, Bldg. 219-2.

Any discrepancies or changes to this TMP shall be brought to the attention of the Project Engineer as soon as noted.

1.1 Blank & Cup

Press: crank, vertical, double action - Bliss No. 6
Tools: Blanking Punch, SKFSA 11205, Rev C
Cupping Punch, SKFSA 11206, Rev C
Blank & Cup Die, SKFSA 11207, Rev E
Stripper, SKFSA 11208
Stripper Spring, PT-1006
Stripper Holder, SKFSA 3682
Gage Limits: SKFSA 9863 - O.D. 0.694-0.700
SKFSA 9864 - Base thick. 0.150-0.156
SKFSA 9865 - Wall thick. 0.180 inside
Base - 0.107-0.127
Wall thick. variation - 0.180 from inside
Base - 0.004 max
Wall height variation - 0.035 max
Weight - 194 grs (approx)
Solution: 1-1/2 parts water to 1 part Lubro No. 44
Hardness: 1/16" from junction of base and sidewall
R_B 80 to 86

1.2 Wash, Rust Prevent

Barrel: metal, rotary, inclinable, Baird
Solution: Hot water, 4 cups tri-sodium phosphate; wash for 1/2 hour; Rust Preventive: potassium dichromate added to final rinse.

1.3 Anneal

Furnace: Lindberg, atmosphere controlled
Temperature: 1320°F
Time in furnace: longest time possible (approx 102 min)
Hardness: 1/16" from junction of base and sidewall
R_B 65 max

1.4 Phosphate Coat & Lubricate

Machine: Ransomatic unit or other appropriate equipment

1.5 First Draw

Press: crank vertical duplex Bliss No. 62
Tools: Punch PT-1291
Guide Ring PT-1966A
Top Die PTC-1982
Bottom Die PTC-1983
Stripper PT-1294A
Stripper Holder PT-1005
Stripper Spring PT-1006
Gage Limits: SKFSA 9866 - O.D. 0.595-0.600
FB 36261 - base thick. 0.150-0.158
SKFSA 9867 - wall thick. 0.437 from inside base
0.058-0.062
wall thick, var. 0.437 from inside base -
0.004 max
Solution: 6 lbs industrial soap chips to 50 gals water. If difficulties are encountered, revert to 4 parts water to 1 part Warco No. 1673
Hardness: 1/16" from inside base R_B 80 to 86

1.6 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 7.5 lbs of Pensalt to 200 gals of H_2O
Rust Preventive: 3 oz of potassium dichromate added to rinse water

1.7 Anneal

Furnace: Lindberg, atmosphere controlled
Temperature: 1320°F
Time in Furnace: longest time possible (approx 102 min)
Hardness: 1/16" above junction of base and sidewall R_B 66 max

1.8 Phosphate Coat & Lubricate

Machine: Ransomatic unit or other appropriate equipment

1.9 Second Draw:

Press: crank, vertical, single action, Bliss No. 304

Tools: Punch PT-1901
Guide Ring FB 52211
Top Die PTC-1902
Lub Ring SKFSA 10768
Bottom Die PTC-121A
Stripper PT-1003D
Stripper Holder PT-1005B
Stripper Spring PT-1006

Gages & Limits: FB 36052 - O.D. 0.516-0.519
SKFSA 9873 - base thick. 0.155-0.165
SKFSA 9874 - wall thick. 1/4" from inside base 0.039-0.045
wall thick var. - 1/4" from inside base 0.005 max
SKFSA 9875-1 1/8" from inside base
wall thick - 0.020-0.025
wall thick var-1 1/8" from inside base 0.003 max

Solution: 6 lbs industrial soap chips to 50 gals water. If difficulties are encountered, revert to 4 parts water to 1 part Warco No. 1673.

Hardness: 1/16" above junction of base and sidewall
R_B 81 to 86

1.10 Wash, Rush Preventive Rinse & Dry

Washer: Niagara - See 1.6

1.11 Anneal

Furnace: Lindberg, atmosphere controlled
Temperature: 1320°F
Time in furnace: longest time possible (approx 102 min)
Hardness: 1/16" above junction of base and sidewall
R_B 69 max

1.12 Phosphate Coat & Lubricate

Machine: Ransomatic unit or ther appropriate equipment

1.13 Third Draw

Press: crank, vertical, single action, Bliss No. 304

Tools:

Punch	PT 1903A	
Guide Ring	SKFSA 10770	
Top Die	PTC 131A	
Bottom Die	PTC 132A	
Stripper	PT1004E	
Stripper Holder	PT1005B	
Stripper Spring	PT1006	

Gages & Limits:
FB 17480 outside dia. 0.4630-0.4642
FB 22303 base thick. 0.165-0.174
FB 23471 wall thick. 1/4" from inside base 0.035-0.042
wall thick, var. 1/4" from inside base 0.006 max
FB 23471 wall thick 1.70 from inside base 0.0095-0.0125
wall thick. var. 1.70 from inside base 0.002 max

Solution: 6lbs commercial soap chips to 50 gals water. If difficulties are encountered, revert to 4 parts water to 1 part Warco No. 1673

Hardness: 1/16" above junction of base and sidewall R_B 73 to 79

1.14 Wash, Rust Preventive Rinse & Dry

Washer: Niagara - See 1.6

1.15 Trim

Machine: horizontal, single spindle

Tools:	Cutter	SKFSA 10268
	Spindle	FA 30254
	Sleeve	SKFSA 6118
	Stripper Ring	SKFSA 6122
	Nut	FA 30255
	Burring Cutter	SKFSA 6119
	Spring	SKFSA 6123

Gage & Limits: SKFSA 9371 - inside length 1.840-1.860

1.16 Sort

Inspection Belt

1.17 Head

Press: Horizontal toggle & crank

Tools:	Die	PT-1462
	Eject Stem	PT-1420
	Punch (1 pc)	________
	Punch (2 pc)	SKFSA-11277
	Punch Holder	SKFSA 11276

Gages & Limits: FB 22321 - outside dia. 0.4645-0.4670
SKFSA 9869 - pocket dia. 0.2077-0.2082
FB 22323 - pocket depth 0.1265-0.1305
FB 22303 - web thick. 0.052-0.062
FB 23482 - pocket concentricity 0.003 max
FB 23330 - head crookedness 0.004 max

1.18 Wash, Rust Preventive Rinse & Dry

Washer: Niagara - See 1.6

1.19 Head Turn

Machine: horizontal single spindle
Tools: Collet PT-1008B
Spring PT-1009
Form Tool FB 52213 (carbide type C6)
Gages & Limits: FC 2884 - head dia. 0.467-0.471
FC 2927 - head thick. 0.048-0.053
FC 2884 - ext groove dia. 0.403-0.407

1.20 Vent & Deburr

Machine: WFF Primer Insert
Tools: Burr
Punch FB 56637
Stem FB 18636B
Vent
Punch Holder PT-170B
Punch FB 36474
Die FB 36475
Stem FB 36476
1st No Vent Detect
Holder PT-176A
Clamp PT-179A
Stem PT-177B
Detect Pin PT-178
2nd No Vent Detect - Same as 1st No Vent Detect
Gages & Limits: SKFSA 9868 - dia. of vent hole
0.078-0.082

Note: Operation and tools mentioned above are to be used when two piece heading punch is used at heading operation.

1.21 Taper & Plug

Press: vertical, double action, crank - Bliss No. 162
Tools: Mouth ironing punch FA 33875
Mouth ironing die PT-1000
Mouth ironing spring PT-1012
Shoulder Die SKFSA 6143
Body Die PTC-1989
Eject Stem PT1918 or SKFSA 6142
Plug Punch PT-159A

1.21 Taper & Plug (cont'd)

Gages & Limits: FB 23520 - profile of body
SKFSA 9870 - mouth dia. 0.3078-0.3085
FB 23522 - length, head to shoulder 1.6295-1.6325
FB 23460 - neck dia. 0.3413-0.3433
Lubricant: machine oil

1.22 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)

1.23 Finish Trim

Machine: vertical, single spindle
Tools:

Cutter	PTC 1010B or SKFSA 6148
Cutter Holder	PT-1011B or SKFSA 6147
Support Cover	PT-1014 or SKFSA 6149
Retainer Seat	PT-1923 or SKFSA 6150
Case Support	FA 33876 or SKFSA 6149
Cutter Clamp	PT-1015A or SKFSA 6149

Gages & Limits: FB 23526 - total length 2.003-2.0093

1.24 Wash, Rust Preventive Rinse &Dry

Washer: Niagara (see 1.6)

1.25 Harden (Temper within two hours)
Machine: Westinghouse induction unit
Hardness: 1/16" above extractor groove -R_C 42-50
Voltage Setting: To be established
Quench Solution: Caustic Soda 6% ± 0.5%
Quench Solution Temp: 60°F ± 5°F

1.26 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)

1.27 Temper (within two hours of Harden 1.25)

Furnace: Lindberg, electric, recirculating air
Temperature: 800°F ± 10°F for 75 minutes
Hardness: 1/16" above extractor groove R_C 22 to 28

1.28 Clean & Rinse

Machine: Blakeslee pickling unit
Cleaning agent to be established

1.29 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)

1.30 Retaper & Replug (if necessary)

Press: vertical, double action, crank - Bliss No. 62
Tools: Plugging Punch PT-159A
Shoulder Die SKFSA 6143
Body Die PTC-1989
Gages & Limits: SKFSA 9870 - mouth dia 0.3078-0.3085
FB 23520 - profile of body
FB 25522 - length, head to shoulder 1.6295-1.6325
FB 23460 - neck dia 0.3413-0.3433

1.31 Wash, Rinse & Dry (if retaper is necessary)

Washer: Niagara (see 1.6)

1.32 Visual Inspect

1.33 Iron Phosphate - to be established
Process will be provided at a later date.
Alternate method - Plating Shop Bldg 46-1

1.34 Varnish - to be established

Process will be provided at a later date.
Alternate method - Ronci varnishing machine and curing oven located in Bldg 39.

1.35 Visual Inspect

1.36 Prime, Load, Gage & Weigh & Inspect

Same machines as shown in the Operations Control Section pertaining to Cartridge, Ball & Tracer, NATO, 7.62mm, M80 and M62.

2. Furnish gages required to accomplish this project

3. Record the following information:

3.1 Number of pieces processed through each operation.

3.2 Amount of scrap obtained at each operation.

3.3 Number of pieces processes by each tool.

3.4 Reason each tool is discarded.

3.5 Amount and cause of downtime.

3.6 Machine speeds.

4. Perform a hardness test on five pieces, taken hourly, from each of the interdraw anneals, the quench harden and temper anneal operations. Submit results to Project Engineer, Mr. W. Weis.

5. Measure five pieces from each cup and draw punch every hour. Record and submit to Project Engineer.

6. Measure five pieces every 30 minutes from the trim operation through all subsequent operations with the exception of taper and plug and retaper and replug (if needed), which shall be measured every 15 minutes. Record and submit measurements to Project Engineer.

7. Submit a copy of the cartridge case 100% visual inspection before and after varnishing operation, the gage and weigh operation, and the 100% cartridge visual inspections to the Project Engineer.

8. Perform a measurement survey (periodic check) on a sample of ten cartridge cases each, taken at the end of each day.

9. Perform a weigh check on samples of ten cartridge cases each, taken from the second 100% visual inspection. The samples shall be taken at the end of each day.

10. Perform a hardness check on samples of ten cartridge cases each taken from the first 100% visual inspection. The samples shall be taken at the end of each day. Take readings at positions shown on drawing No. D10521997. Readings shall be taken similar to brass case using Vickers DPH and 2-1/2 K_g load. Once each week ten cases shall be sectioned, one-half section mounted and hardness tests taken at the same positions on the sectioned sidewall using Vickers or Tukon DPH with a 2-1/2 K_g load.

11. Perform a hardness test on the strip at the beginning and end of each coil. Use Rockwell "B" scale.

12. Supply a sufficient quantity of Bullets, Ball, NATO, 7.62mm, M80 for loading and assembling 750,000 Ball, M80, Cartridges.

13. Supply a sufficient quantity of Bullets, Tracer, NATO, 7.62mm, M62 for loading and assembling into 250,000 Tracer, M62 Cartridges.

14. Supply a sufficient quantity of No. 34 primers for tests and one million production quantity.

15. Supply a sufficient quantity of Western Ball, WC846 propellant to accomplish testing and the one million production quantity.

16. Maintain identity of work through all operations.

17. Furnish a complete cost breakdown of expenditures to Project Engineer, Mr. W. Weis.

18. Forward quantities of cartridges specified by Project Engineer to Engineering Proof Testing Laboratories, J9200, when requested.

19. Pack cartridges when requested.

20. Remove tools from machine as each operation is completed and store properly identified, unless otherwise specified.

21. Manufacture additional tools, if required.

Pitman Dunn Research Lab, L1000
Mechanical Metallurgy Branch, L7200

22. Furnish photomicrographs of the steel strip microstructure - 750 magnification.

23. Furnish photomicrographs of samples of three components each, taken from the interdraw anneals, hardening and tempering operations. Photomicrographs shall be taken of the middle wall area using 750 magnification.

24. Examine a sample of five cartridge cases each for cold shut determinations. Take photomicrographs (100 magnification).

Test & Evaluation Division, Q6000
Basic Materials Evaluation Branch, Q6100

25. Perform a wet chemical analysis on a sample of steel cartridge case strip from each heat of Sharon Steel.

26. Perform hardness determinations as requested by Project Engineers.

Environmental Branch, Q6200

27. Perform salt spray test using 5% and 20% solutions on a sample of five cartridge cases. Method of test shall be in conformance with Federal Test Method Standard No. 141.

28. Perform salt spray tests utilizing 5% and 20% solutions on samples of five cartridges. Method of test shall be in conformance with Federal Test Method Standard No. 141.

Ammunition Development & Engr Lab, J4000
Metallurgical Engr Branch, J4400

29. Forward samples of cartridge case steel strip (Sharon Steel Co) from both heats of steel to Basic Materials Evaluation Branch, Q6100, for wet chemical analysis.

30. Forward samples of the cartridge case steel strip (Sharon Steel Co) from both heats of steel to Mechanical Metallurgical Branch, L7200, for photomicrographs of grain structure.

31. Forward three components from each interdraw anneal, hardening and tempering operation to Mechanical Metallurgical Branch, L7200, for photomicrographs of grain structure.

32. Forward five headed components to Mechanical Met Branch, L7200, for cold shut determinations and photomicrographs.

33. Provide metallurgical technical assistance where and when required.

Chemical Engr Branch, J4300

34. Forward samples of varnished cartridge cases and cartridges assembled with varnished cases to Environmental Branch, Q6200, for salt spray testing.

35. Provide chemical technical assistance where and when required.

Small Caliber P&M Engr Lab, J9000
Ammunition Engr Branch, J9100

36. Forward samples of finished cases to Basic Materials Evaluation Branch, Q6100, for hardness determinations.

37. Provide technical assistance relative to tooling and process where and when required.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U.S. Army Munitions Command Dover, N. J.

13. ABSTRACT

Under the Copper Conservation Program, a process was established and pilot facilities set up at Frankford Arsenal for the production of a heat treated steel case for 7.62mm cartridges.

Work was based upon a previous attempt to develop a 7.62mm steel case which was partially successful. Small lots of cases were manufactured until a satisfactory process was obtained. The process thus developed was used for production of one million ball and tracer cartridges which were submitted for ET/ST.

Report covers process development, process metallurgy, processing methods, test results, and quality assurance.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Cartridge Cases						
Small Caliber Ammunition						

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